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COLLEGE CHEMISTRY

IN

NURSING EDUCATION

A STUDY OF COLLEGE COURSES AS A FOUNDATION FOR BASIC PREPARATION

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To CHARLOTTE ANN FRANCIS

whose teaching of chemistry demonstrated that an applied course can provide an experience which is scientifically sound, professionally valuable, and rich in cultural interest.

PREFACE

The study presented in this monograph has developed out of the author's interest in the preparation of professional nurses. To render the finest quality of nursing service requires, not only those personal characteristics which are generally recognized as of primary importance, but also the command of reliable knowledge of the facts and scientific principles which underlie all good nursing. Nursing practice which runs counter to sound scientific principles defeats its own end, and the plea of ignorance cannot undo the injury. Consequently, a good foundation in science is essential for safe and effective nursing.

As a nurse whose field of specialization is the teaching of chemistry, the author naturally takes particular interest in problems in nursing education which relate to this area. The study herein presented deals specifically with the practice of using standard college courses in general chemistry in the basic preparation for nursing. An attempt has been made to evaluate this practice both as to the contribution of such courses and their limitations for this purpose. The frequency with which questions relating to this usage are raised suggests that nurses will be interested in such a study. The issue is one concerning which there are honest differences of opinion. Some nurse educators strongly advocate use of the standard chemistry courses for nurses as for other college students; others hold that the type of course prevailing in the college does not provide a functional foundation for the study of nursing. The current trend toward affiliation of schools of nursing with colleges and universities makes consideration of this problem particularly timely.

The content is organized in two sections. Part I contains the statement of the problem and the plan for study, also the general discussion and evaluation of the college offering. Using the results of the evaluation of the course in general chemistry, suggestions are made for provision for further study of chemistry by students in nursing through a course designed with reference to their special needs and interests. The outline of content for such a course, together with some suggestions for its development, constitute Part II of the monograph.

In the general discussion some attention is given to differences in historical background and educational philosophy which condition the thinking of educators in both colleges and schools of nursing. Better understanding of these differences might lead to better mutual understanding of the problem under consideration. The author is conscious that her own point of view has been strongly influenced by her experience as a nurse, and that her thinking is biased in favor of science courses that have practical significance for the students. The word practical is used with this meaning, that the study should be so organized and so guided that the student acquires a knowledge of the basic principles of the science and also learns to apply these principles in the solution of problems relating to his practice.

The study should interest administrators whose work involves responsibility for development of a nursing curriculum, as well as the teachers of chemistry. This problem is likely to arise in any school of nursing which is co-operating in or planning for a college affiliation, also in schools which require some college preparation for admission. Teachers of chemistry in colleges that offer programs in nursing may be interested in the discussion. Some of the suggestions may help to clarify the question of what type of course nurses have in mind when they urge that chemistry be taught in such a way as to be of functional value for students in nursing. Nurses who have made the teaching of science their field of specialization may find suggestions for development in their own courses. As members of the faculty who have special responsibility for the quality of science in the curriculum of the school of nursing, they will probably be interested in various phases of the study.

A word of explanation is in order regarding the selection of references for the units in Part II. These are almost all from secondary sources. In this connection, it was considered that the references should be suitable for the use of young college students, also that they should be readily available for all schools of nursing. Much of the material in the *Annual Review of Biochemistry* is too difficult for student use but for the teacher this is a valuable source of up to date information — both the reviews themselves and the extensive bibliographies.

The author gladly acknowledges her indebtedness to many persons who have contributed to this study, some by helpful suggestions; others by the encouragement provided through their expressions of interest in the work. She wishes to thank the writers and publishers who gave permission for use of quotations; also the following teachers who made suggestions regarding selection of textbooks for the evaluation of content in college chemistry: Professors Alexander Calandra, John R. Lewis, Rufus D. Reed, and O. M. Smith. She is especially grateful to the following persons who read the manuscript at various stages and whose criticisms and suggestions contributed much to its development: Professor Isabel M. Stewart who counselled wisely out of her rich knowledge of nursing education; Professor Donald P. Cottrell who advised particularly in relation to the college curriculum; Professor Natalie K. Fitch of the Department of Home Economics; and Charlotte A. Francis, formerly Instructor in Chemistry at Teachers College, who read the manuscript with an eye to the treatment of chemistry. The author assumes the responsibility for the study as a whole, the point of view expressed, and any errors.

EDNA C. MORSE

CONTENTS

PART I

The Introductory Course in College Chemistry as a Foundation for Chemistry in the School of Nursing

CHAPTER PAGE
I. The Problem in Its Setting 3
II. Chemistry within the Curriculum of the School of Nursing 20
III. The Introductory Course in College Chemistry—its Contribution to the Curriculum in Nursing . 54
IV. Proposals for a Chemistry Course for the School of Nursing — to Follow an Introductory Course in College Chemistry 90
V. The Next Step — to Build Chemistry into the Nursing Experience.......................... 108

PART II

Outline for a Chemistry Course in the Nursing Curriculum — to Follow an Introductory Course in College Chemistry

Introduction.............................. 122
UNIT
I. Reactions of Acids, Bases, Salts, and Water — Their Applications in Nursing................. 123
II. Important Classes of Organic Compounds and Some of Their Relations to Nursing 129
III. Carbohydrates, Fats, and Related Compounds — as Substances of Biological Importance........ 144
IV. Cyclic and Heterocyclic Compounds — with an Introduction to Some Important Drug Groups.. 157

UNIT PAGE
V. Proteins — Their Nature and Peculiar Importance in the Life of the Organism 168
VI. Vitamins (an optional study) 174
VII. A Study of Digestion with Special Consideration of Enzymes 180
VIII. Metabolic Reactions — The Functioning and Fate of Oxygen, Glucose, Fats, and Proteins Within the Cells 188
IX. Maintenance of the Environment of the Living Cells — Integrated Functioning of Blood, Lungs, and Kidneys 199
X. Other Important Functionings of Salts 206
XI. Radioactive Elements — Their Biological Interest (an optional study) 212
Appendix Comparison of Textbook Content 218

CHARTS

PAGE

I. The Chemistry Course in the Three-Year School of Nursing 44

II. Chemistry in Schools of Nursing with Programs Leading to Degrees 48

III. Objectives in Teaching General College Chemistry, as Reported in Studies and Expressed by Teachers of Chemistry 66

IV. Comparison of Objectives of the College Course in Chemistry with Those of the School of Nursing 70

INTRODUCTION

Most of the volumes in this series of monographs are planned with reference to rather broad aspects of nursing education — teaching, supervision, administration, or the education of nurses in general. This volume deals with a relatively specialized problem, one that is of particular interest to teachers of chemistry in nursing schools and in colleges. The value of this study, however, is by no means restricted to these groups. The problem discussed is one that is met by curriculum planners in many professional fields. It is of special concern to those responsible for curriculum planning in schools of nursing or in prenursing college programs and it throws light on some interesting aspects of the historical development of both college and nursing school programs. Admissions officers who evaluate the records of applicants to nursing schools and advisers of such applicants before and after admission will also find some helpful suggestions in this study.

There is another group that the publishers and editor have had in mind in adding this book to the *Macmillan Nursing Education Monographs.* That is the growing group of advanced students and others who are beginning to probe more deeply into nursing problems and to experiment with various research and study methods. This is still a frontier area in nursing and it is very important that encouragement and assistance be given to those who are pioneering in it. The nursing profession is indebted to both authors and publishers who help to open up this new area and to make studies like this available to those who are interested in special aspects of nursing education.

ISABEL M. STEWART

PART I

The Introductory Course in College Chemistry as a Foundation for Chemistry in the School of Nursing

Chapter I

THE PROBLEM IN ITS SETTING

No school of nursing has a right to call itself a school unless it accepts education as its primary function. . . . As a professional school it should provide for its students an educational program which includes those elements that are characteristic of true professional education and which is planned with special reference to both student needs and the health and sickness needs of the community. In addition, it should provide the conditions essential to making such an educational program effective.[1]

INTRODUCTION

Education of professional standard for nurses. The school of nursing which claims to offer professional preparation should give serious consideration to the provision it makes for teaching the sciences. The competence of its graduates depends not only on their technical proficiency and skill in nursing arts but also on their knowledge of underlying scientific principles and ability to use these principles in practice. Without a good functional knowledge of this basic science, the nurse becomes either a routine worker or one who solves her problems by empirical methods; she is not a truly professional worker.

The claims of nursing to professional status are based on the responsible services which nurses render to the public. Although care of the sick is one of their major responsibilities, they also occupy important positions in the community as teachers, counselors, and leaders in matters relating to health.

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[1] *Essentials of a Good School of Nursing*, 2nd ed., New York, Committee on Standards, National League of Nursing Education, 1942, p. 1.

Competent practice calls for the exercise of judgment, resourcefulness, and initiative, and the discharge of these functions and responsibilities requires the command of a substantial body of knowledge pertaining to health, disease, and nursing procedures. Therefore, safe and effective nursing practice demands preparation of professional character. The school of nursing which undertakes the preparation of professional workers is obligated to its students, the public, and the nursing profession to develop a curriculum of professional standard, adapted to the occupational needs of nurses.

One essential characteristic of professional education is that a good foundation is laid in the science and theory on which the practice is based. The professional worker is expected to understand these principles and to use them for directing his work, for adapting procedures to specific situations or emergencies, and for the evaluation and improvement of existing practice. Moreover, this foundation is expected to serve as the basis for the independent reading and study whereby the worker gathers needed information, keeps pace with new developments in his field of specialization, and continues his professional growth.

Knowledge of biological and physical science — especially those phases pertaining directly to his work — has become indispensable for the professional worker, in any field closely related to medicine and health. Care of the sick and prevention of disease have come to depend more and more on the application of knowledge derived from these sciences. Consequently, they should have an important place in the basic curriculum[2] of the school of nursing. The sciences now generally included in this program are anatomy and physiology, microbiology, and chemistry. The present study deals with the teaching of chemistry and discusses the use of introductory courses in college chemistry as a means for strengthening the science foundation in the nursing curriculum.

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[2] The term "basic curriculum" is used to designate the curriculum provided by a state-accredited school of nursing, the completion of which qualifies the student to admission to examination for license to practice as a registered nurse.

COLLEGE CHEMISTRY IN RELATION TO THE BASIC CURRICULUM IN NURSING

Although chemistry is now generally accepted as a necessary part of the preparation in nursing, wide differences of opinion exist among nurses as to both the character of the course and the extent to which this subject should be developed in the basic curriculum. There has been a good deal of justifiable criticism of the inadequacy of the brief applied courses which prevail at present in most schools of nursing. Some schools have thought to shift to the college the responsibility for the foundation in chemistry and, by this means, to relieve themselves of the necessity for teaching this subject. Others doubt the adequacy of this plan.

The use of college chemistry merits consideration. Schools of nursing find among the students admitted with some college preparation a fairly large proportion who already have had at least an introductory course in chemistry but only occasionally one who has completed the sequence of general, organic, and physiological chemistry. Almost any student who enters college with the intention of subsequently studying nursing will be advised to include chemistry in her program. Sometimes a school of nursing prescribes this subject as an admission prerequisite. Even the student who had no intention of becoming a nurse when she entered college may have included chemistry in her program. Schools of nursing, therefore, frequently face the necessity of adopting some policy with regard to the introductory course in college chemistry in relation to their own curriculums.

The problem stated. Neither the policy of completely ignoring the contribution made by the college course nor that of accepting such a course for credit with little or no evaluation as to its adequacy as a foundation for the program in nursing commends itself as justifiable. Before a valid policy can be established and justifiable practice instituted, answers to the following questions should be sought and obtained.

1. What contribution can the usual introductory course in college chemistry[3] make to the basic program in nursing?
2. What further development is needed to assure the foundation in chemistry that is essential to a good basic professional program?

When answers to these two questions are obtained, it should be possible to formulate a course in applied chemistry, which will use the college experience but avoid undue repetition of work already familiar to the student through previous study. The need for a supplementary course is anticipated because the college course, as part of a program of general education, should not be expected to deal with the special problems of any one vocational group. By accepting the general course and supplementing it with one which focuses directly on nursing, it should be possible to build a much better foundation in chemistry than either the college course or the short applied course in current use can provide alone. With such a program, the college student should find that her knowledge of chemistry is enlarged through the professional study; also that her previous experience becomes more meaningful and of greater functional value because of relationships established with her chosen vocational field.

Trends in nursing education which make study of the college offering in science an urgent problem. The possibility of using college courses in science as part of the foundation for the nursing curriculum has been for years a recurrent issue.[4] As nursing moves toward the establishment of an educational program of recognized professional standard, the need for study of this problem becomes more urgent. Two modern developments which make this study of immediate importance are:

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[3] The introductory college course is sometimes referred to as the course in general chemistry, sometimes as a course in inorganic chemistry. In either case, it will be found to treat primarily with the principles of the science as they relate to elements and inorganic compounds.

1. An upgrading of admission standards by schools of nursing, accompanied by a notable increase in the number of students who already have had some college preparation.
2. An increasing number of schools of nursing with college affiliations offering a combined general and professional program.

The admission of students better prepared academically calls for adjustments in the curriculum of the school which shall be consistent with this higher level of preparation.

The upgrading of admission standards. In the past, a variety of factors have operated to keep the academic standards for admission to schools of nursing below those of most professional groups. The present increase in students with college experience is, to some extent, a natural result of the increased proportion of young people in America who now complete secondary education and go on to college. But it should also be attributed to a definite effort on the part of organized nursing to attract better-prepared candidates. Concrete evidence of the trend toward establishment of higher admission standards is provided by the following facts:

1. All state boards regulating the practice of nursing now recognize high-school graduation as the minimum standard for admission to accredited schools.
2. Many of the more progressive schools have already raised their own requirements to the completion of one or more years of college. Other schools, although still adhering to high-school graduation as the minimum requirement, give

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[4] See p. 41.

preference to applicants who have had college experience, and these schools show a relatively high proportion of such students in their enrollments.

3. The National League of Nursing Education has made the following recommendation:

> An advance of two years of general education beyond high school is recommended as the general education requirement which schools of nursing should seek to establish. This requirement tends to secure students of greater maturity and provides a broader foundation on which to build professional preparation.[5]

Evidence that these factors are producing results is seen in the increase in the proportion of students with college preparation actually enrolled in the schools of nursing. Whereas a study made in 1932 by the Committee on the Grading of Nursing Schools indicated that only *6 per cent* of the students then enrolled had had any college experience, a study published in 1944 by the National League of Nursing Education showed that *13 per cent* of the enrollment had attended college. Of these, 8 per cent had completed one year of college, 4 per cent had completed two years, and 1 per cent from three to four years.[6]

The abnormal pressure of war functioned to some extent to check this upward trend in the hospital school.[7] The demands upon schools of nursing for increased enrollments to meet the war emergency resulted in the acceptance of high-school graduates who might otherwise have been encouraged to go on to college before entering the school of nursing. Moreover, many of the young women who were interested in preparing for nursing indicated a decided preference for the schools which offered a combined general and professional program.

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[5] *Essentials of a Good School of Nursing*, p. 20: also see *A Curriculum Guide for Schools of Nursing*, New York, Committee on Curriculum, National League of Nursing Education, 1937, p. 36.

[6] "Educational Qualifications of Student Nurses," Department of Studies, National League of Nursing Education, *American Journal of Nursing*, Vol. 44, March, 1944, pp. 262–264.

[7] "First-year Students — Their Education," Department of Studies, National League of Nursing Education, *American Journal of Nursing*, Vol. 45, March, 1945, pp. 228–231.

The trend toward college affiliations. The development of schools of nursing under college auspices also has direct bearing on the issue of use of college offerings in science as part of the nursing curriculum. The following facts give some indication of the extent of the trend toward college affiliation. The first school of nursing to offer a basic curriculum under university auspices was opened in 1909 at the University of Minnesota. By 1923 there were 16 nursing schools associated with colleges or universities.[8] A study made in 1937 reported 66 schools of nursing offering degree programs.[9] In 1943 the National League of Nursing Education listed 136 schools with basic programs leading to a college degree. One of the outstanding arguments advanced for this development is that the science foundation for the professional program will be materially strengthened through use of the resources of the college.

Both the hospital school admitting students with college experience and the collegiate school developing a combined general and professional program should consider how the college experience can be used to greatest advantage in continuing the professional education.

Arguments for the use of standard college courses. The arguments which are commonly advanced by educators who advocate the adoption of the college courses in science are as follows:

1. That instruction by a teacher who is a specialist in his subject, and the superior laboratory facilities of the college,

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[8] Josephine Goldmark, *Report of the Committee on Nursing and Nursing Education in the United States*, New York, The Macmillan Company, 1923, p. 24.

[9] Lucile Petry, "Basic Professional Curricula in Nursing Leading to Degrees," *American Journal of Nursing*, Vol. 37, March, 1937, pp. 287–297.

should result in more thorough knowledge of the science than can be expected from the short applied courses so generally found in schools of nursing.

2. That to require the completion of one or more science courses as prerequisite for admission to the school of nursing should make it possible to relieve some of the pressure now evident within the three year nursing curriculum. It might even make acceleration of the program for well-prepared applicants a practical possibility.
3. That other professional groups quite generally use the standard college courses in science as a basis for their professional program. Is an exception for students of nursing justifiable?

Further argument for consideration of the contribution of college science courses comes from the college student herself. When such a student is thinking of nursing as a career she, quite reasonably, inquires as to credit granted for science courses completed satisfactorily in college. She considers it to be somewhat unreasonable that these should be wholly disregarded in favor of brief applied courses in which the fundamentals of the sciences are repeated — often with less thorough treatment than was accorded them in the college course. The more discerning applicant may even question the quality of the clinical program which is based on such brief study of the sciences. In view of the fact that the nursing profession is definitely interested in attracting well-educated, intelligent young women, a curriculum policy which functions to discourage such applicants warrants careful examination.[10]

The other side of the question. On the other hand, many experienced teachers doubt the soundness of the suggestion that the conventional college course can be relied upon to provide the needed foundation for the study of nursing. They make the following observations:

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[10] Edith H. Smith, "Educators Look at Nursing," *American Journal of Nursing*, Vol. 43, June, 1943, pp. 573–576.

1. Many students who made good records in college courses in science before they entered nursing fail completely to recognize significant relationships between the information acquired in these courses and its application in nursing. Indeed, even interrelationships which exist between the sciences may not be recognized.
2. Considerable portions of the science content of the usual college courses have little or no relation to the work and interests of the nurse, whereas other areas quite as essential for professional preparation either are not included or receive only superficial treatment in courses designed for general education.
3. When the study of science is part of a program of general education which precedes and is separated from the nursing experience, a valuable opportunity for motivation is lost. For some students, the motivation provided is a determining factor as to both the interest and the effort which goes into the study, and consequently in the learning which results from the course.

These experienced teachers contend that courses planned with the specific needs and interests of the students as the basis for selection and treatment of content, despite their apparent limitations, may actually prove of greater functional value for the student of nursing than do the usual science courses in the college curriculum.

The consensus of opinion of the Committee on Curriculum of the National League of Nursing Education was that "general college courses in science, while of undoubted value, do not entirely take the place of courses which are set up especially to meet professional interests and needs."[11]

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[11] *A Curriculum Guide for Schools of Nursing*, pp. 141–142.

Specific situations in which the problem of college chemistry is encountered. The problem relating to college chemistry and the nursing curriculum is pertinent for study in each of the following situations:

1. A school of nursing is admitting a number of students who have completed introductory courses in college chemistry. Shall such students be required to take the course in applied chemistry in the nursing-school curriculum? Shall they be granted exemption from part or all of the applied course? If some adjustment is to be made, what modifications are indicated in relation to the existing course?
2. A school of nursing has under consideration adoption of the policy of requiring a course in college chemistry as prerequisite for admission. If this becomes its practice, will the school of nursing be relieved of the necessity of including chemistry within its own curriculum? If not, how will the college course affect the character of the course developed in such a school?
3. A school of nursing is considering affiliation with a college and planning to include chemistry in the part of the program to be taught by the college. Shall the students in nursing be admitted to the regular courses in chemistry on the ground that the principles of the science are the same regardless of the field of application, or shall a special course be developed because a unique selection and treatment of the subject is desirable for the student in nursing? It must be remembered that in the combined liberal arts-professional program, the period at the college is supposedly designed quite as much for general education as to serve professional needs. Many educators feel rather strongly that courses included in this period should not be highly specialized. Consequently the college may prefer, if not insist, that students in nursing take the usual

course in chemistry along with other students. This is, perhaps, the easiest way to settle the problem, but is it the best? If such is the decision, should not the committee responsible for the professional curriculum consider to what extent this general course should be supplemented in order to make adequate provision for the development of a good basic curriculum in nursing?

Information needed in these situations. Decisions are being made wherever such situations arise. But, considering the dearth of objective information, such decisions frequently must be based on the opinions of individuals or interested groups whereas reasonable determination of a consistent policy, in any of these situations, should require:

1. Investigation of the work of the nurse and of the foundation in chemistry which is essential to enable her to perform this work intelligently and effectively, and to make reasonable provision for her continued professional growth.
2. Investigation of the offerings in college chemistry, especially in relation to the character and content of the introductory courses in liberal arts and preprofessional programs.

Chemistry content of the nursing curriculum. The National League of Nursing Education has made study of the basic curriculum of the school of nursing one of its major concerns. It has conducted periodic studies out of which has developed a *Curriculum Guide*, designed for the purpose of offering constructive suggestions to schools of nursing for working out their own educational programs. Nurses from many parts of the country, as well as others interested in the teaching of chemistry in schools of nursing, co-operated in constructing the course outline in chemistry which appears in the current publication.[12] This outline represents the most definite formulation of group opinion on this subject which has been developed up to the present. Undoubtedly there are differences of opinion among nurse educators as to the degree to which the content selected represents the chemistry requisite for the basic preparation of nurses. Indeed, it is probably fair to say that it comprises only those essentials on which a representative group of nurses were able to agree as providing a working basis from which individual schools can develop their own courses. This outline is still in advance of current practice in many schools. Even so, parts of it should now be revised to bring the content in line with recent developments in chemistry which affect nursing practice. Nevertheless, this outline still provides the best standard at present available for comparison of the contribution of general college chemistry with the chemistry content which is generally accepted as important for inclusion in the basic curriculum of the school of nursing.

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[12] *A Curriculum Guide for Schools of Nursing*, pp. 168–192.

Evaluation of the college course. If the needs of the student in nursing are agreed upon, there still remains the problem of evaluating the college course in chemistry in relation to these needs. For this interpretation, the school of nursing naturally turns to the college. But the professor of chemistry, although a specialist in his own field, finds it quite as difficult to think of the college course in terms of its contribution to the curriculum in nursing as it is for the nurse to evaluate the college offering. This fact is not always recognized. Clear thinking on this issue is further complicated by differences in educational philosophy which can be accounted for in the strikingly different backgrounds of the institutions concerned.

The academic versus the professional viewpoint. The liberal arts college has a long history of intellectual leadership which gives it a position of prestige. The school of nursing, by contrast, has a decidedly nonacademic background and history. Consequently, there is a disposition on the part of the school of nursing to look up to the older institution with considerable awe and to accept rather uncritically the claims made for its offerings. On the whole, the attitude of the college professor toward a course designed to serve vocational ends has been, and still is, somewhat intolerant. This attitude has been evident in discussions relating to the teaching of chemistry in nursing schools. Claims for the superiority of college chemistry courses have been that they offer a broader foundation; that the logical treatment of the subject, characteristic of the college course, provides the intellectual discipline which is essential for real understanding of science; that transfer of principles of chemistry thus logically developed to use in the practical setting is easily accomplished by the disciplined mind. Furthermore, the vocational group interested in developing a course which will contribute directly to practical ends meets with the criticism that such a development will result in a narrow and superficial preparation which, in the long run, will be detrimental to the best interests of the student.

Those who are concerned with the education of nurses and who covet for them the resources of the college are familiar with this point of view. But, in evaluating the arguments offered in justification of the conventional college courses in chemistry, they too frequently fail to recognize to what degree these arguments originate in deeply rooted academic traditions rather than from any firsthand effort on the part of college teachers to determine whether these courses in chemistry are, in fact, appropriate to the needs and interests of the student group under consideration. Admittedly, this represents a conservative point of view which is not shared by all college educators.

Some educators adhere to the more liberal philosophy which recognizes the needs of the student and of the society in which he lives as the focal point around which the educational program should develop. Where this exists, there is a greater possibility for unbiased evaluation of college chemistry through the mutual efforts of teachers of chemistry in the college and teachers who bring to the study both professional experience as nurses and reasonably good preparation in chemistry.

Nurse educators, likewise, approach the study of the college offering with a bias arising from their peculiar education and experiences. Having been nurtured in an institution which places great value on the ability of the individual to deal effectively and adequately with practical situations, they usually approach curriculum problems with an ingrained disposition to evaluate each subject in terms of the contribution which it promises to make toward better nursing practice. Because they are anxious that the selection of content and method of treatment shall be favorable for integration of chemistry within the total pattern of nursing practice, they are inclined to prefer the course which makes direct application of chemistry to the work of the nurse. Experience with college chemistry has left doubts in the minds of many members of the profession as to whether the courses in general chemistry offered by the great majority of colleges can justify the claims made for them. Transfer of academic precept to professional situations does not come easily for most students; and students frequently give the impression of having seen little beyond the immediate details of laboratory technique. Nurses, on the whole, are sympathetic to the idea that more attention should be given to cultural values within the nursing curriculum. They are skeptical, however, of the point of view which implies that a chemistry course cannot combine cultural values with a practical orientation.

Unfortunately, the strong tradition which has encouraged nurses to rely upon authority rather than to depend upon their own findings and judgments likewise conditions their attitude toward the college. The college is the recognized authority in matters pertaining to education. Consequently, when the college professor belittles the applied course in chemistry, the faculty of the school of nursing finds itself halting between two opinions: its own fundamental belief in the value of study directly related to practical experience, and its inclination to accept the evaluation of the college professor.

The importance of evaluating the college course. The school of nursing may rid itself of a troublesome problem by accepting the college chemistry course at face value; but has the problem been solved? Does the school of nursing really know how far the college course goes toward meeting the needs of its students? Does it know wherein the foundation is strong and can be used to advantage and wherein it needs to be enlarged or strengthened to provide for the specific needs of this group? It is in an attempt to find a more satisfactory basis than appears to exist at present for meeting this problem that the present study has been undertaken.

Not the only solution for the problem. The articulation of the standard college chemistry course with an applied course, developed within the nursing curriculum, is not the only plan which might be followed by the school of nursing which has access to the resources of the college. It is not necessarily the plan which will result in the best program for the student in nursing. For the school that makes a course in college chemistry prerequisite for admission, or which finds that its enrollment shows a high proportion of students who have completed such a course in chemistry, the plan is a reasonable one to consider. For some schools of nursing associated with colleges for a combined general and professional program, the combination of general chemistry and an applied course may provide the most desirable solution. But such a plan is not without its disadvantages, some of which will become evident as the present study progresses.

It is strongly recommended that schools of nursing, which are developing their curriculums in association with colleges and universities, should also give thoughtful consideration to the possibility of developing chemistry courses which will serve both cultural and professional needs. Courses can be designed which, from the beginning, minister to professional needs and yet have broad cultural outlooks and good academic standards. Such courses might make even better provision for the all-round development of professional women.

Summary of the Plan of Study

It is proposed, first, to study the situation in schools of nursing with relation to the teaching of chemistry. The next step will be to examine the college offering, especially the content of the general chemistry course, to determine what common core of experience can be expected from such courses. A comparison will then be made of the content of the general chemistry course with that for the school of nursing, as suggested in the *Curriculum Guide.* In this way, information will be gathered as to the extent to which the two programs overlap and as to areas in which significant differences and shortages are apparent in the college course in relation to the nursing program. The plan for an applied course to supplement the college course will then be presented. In developing the supplementary course, specific provision will be made for integration of pertinent material gleaned from the college course with the more specialized content of the advanced applied course.

Underlying the entire study is the assumption that the school of nursing regards itself as an educational institution engaged in the preparation of professional workers, consequently, that the educational level of its curriculum will be the same as that of a good college program. The point of view is that of a nurse with experience as a science instructor, and reflects a different background from that of the subject-matter specialist usually found as a teacher of college chemistry.

The problem presents not only a task but a challenge and an opportunity. The time is ripe for a better program in chemistry in the school of nursing. The school of nursing is entering upon a period when it will need to reconsider its whole educational program. A stronger provision in chemistry would make possible the enrichment of many parts of the nursing curriculum.

Chapter II

CHEMISTRY WITHIN THE CURRICULUM OF THE SCHOOL OF NURSING

The question is not how closely can the educational program be limited, but how much can be woven into its fabric, not for the purpose of accumulating knowledge for itself alone, but in order to better meet the innumerable conditions and situations in which nurses must participate.

—Effie J. Taylor.[1]

The establishment of an adequate foundation in biological and physical science, within the basic curriculum, is a matter of crucial importance for schools of nursing. A good foundation in science is essential for the support of a well-developed clinical program; a poor foundation in science deprives the clinical study of a very necessary resource.

The average school of nursing has never had a strong science program. The offerings of many schools have been pitiably inadequate. One result is the inescapable fact that many nurses now in active practice are carrying on their work with meager understanding of underlying principles. Evidence of this weakness is discernible in the failure on the part of both graduate nurses and students consciously to apply scientific principles in practice. It is seen in the hesitancy of the average nurse to commit herself to scientific interpretations of her practice. It is apparent in her tendency to take refuge in the words of the printed page when her own knowledge should provide adequate explanation. It is evident in the dearth of contributions to professional literature in which good use is made of the sciences in discussion of nursing practice.

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[1] Effie J. Taylor, "The Right of the School of Nursing to the Resources of the University," *American Journal of Nursing*, Vol. 34, December, 1934, p. 1193.

This situation is a not unnatural outcome of the traditional apprenticeship system of education from which nursing is even now struggling to emerge. The close association of the school of nursing with the hospital provides an indispensable and invaluable educational opportunity for the student of nursing, but the economic dependence of the school and the subordination of its educational needs and interests to the demands of the nursing service have greatly hampered the development of a well-balanced curriculum.[2] There has been overemphasis on details of nursing routine, while the study of principles, which should go hand in hand with the study of procedure, has been neglected. Every nurse recognizes that the care of the patient is the heart of the nursing curriculum, and the special interests of most of the faculty of the school of nursing center in this area. What is not yet clearly recognized is that, for the development of nursing art and understanding of the problems relating to disease, the student must continually draw upon the biological and physical sciences for both facts and principles.

THE NEED FOR BETTER PREPARATION IN SCIENCE

The advance of medicine from empirical practice to procedures based on scientific knowledge has been one of the notable developments of the last century.[3] The application of new knowledge in biological and physical science is having a profound effect not only on medical practice but also on nursing. This means that the modern nurse needs better preparation in these sciences in order to keep pace with new developments in nursing practice. To quote from the writings of a prominent leader in nursing education:

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[2] The reader who is not already familiar with the history of the development of nursing education in the United States will find the following references to be excellent sources of information with relation to this problem: M. Adelaide Nutting, *A Sound Economic Basis for Schools of Nursing and Other Addresses*, New York, G. P. Putnam's Sons, 1926; Isabel M. Stewart, *The Education of Nurses: Historical Foundations and Modern Trends*, New York, The Macmillan Company, 1943.

[3] An interesting discussion of this development is found in Bernhard J. Stern, *Society and Medical Progress*, Princeton, N. J., Princeton University Press, 1941, pp. 41–78.

> Nursing, although a different profession than medicine, is its collaborator, and must change its function and scope as medicine enlarges its vision through scientific research. The two professions must grow together, but they cannot do so until nursing is free to develop its educational ideals along scientific lines and until it is recognized that a body of fundamental theory is essential to the perfection of the practice of nursing technic.[4]

The need for better preparation in science is implied in the following statement made by a member of the medical profession:

> You are all aware of the fact that at the turn of the century modern medicine was just emerging from its chrysalis. Empiricism was retreating before the advance of Science. . . . These changes in medical practice imposed new duties and responsibilities upon the nurse, calling for greater knowledge of the manifestations of illness, of the sciences underlying clinical medicine and of the newer methods of therapy; necessitating a broader and more fundamental education and a more thorough preparation for her professional service.[5]

This need is also recognized in the field of public health. It has been identified as one of the factors which hampers the development of creativeness and self-direction among public health nurses.[6] And, it cannot be disregarded when considering the responsibilities and opportunities of nurses as teachers and interpreters in matters relating to health.

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[4] Effie J. Taylor, *op. cit.*, p. 1194.

[5] Arthur C. Bachmeyer, "The Contribution of the Association of Collegiate Schools of Nursing to Nursing Education," *Proceedings of the Fifth Annual Meeting of the Association of Collegiate Schools of Nursing*, (mimeographed), 1938, [p. 50.]

[6] Leah M. Blaisdell, "Preparation of the Nurse of the Future," *American Journal of Public Health*, Vol. 29, May, 1939, pp. 467–472; also see Hugh Cabot, "The Place of Nursing in Health Service," *Public Health Nursing*, Vol. 35, April, 1943, pp. 181–184.

The first attack upon the problem should be through strengthening the science courses in the basic curriculum. However this is only the *first step.* The desired result will not be accomplished until the sciences have become part of the warp and woof of the fabric of nursing practice.

THE CONTRIBUTION OF CHEMISTRY TO THE NURSING CURRICULUM

A really good foundation in chemistry can make invaluable contributions to the nursing curriculum. Yet the almost casual treatment which this science still receives in many schools of nursing suggests that it has yet to impress itself upon nurses as of major importance. Few studies are more rewarding to the student of nursing than is chemistry, when it is well understood. Comprehension of the principles of nursing is deepened because medical science becomes more meaningful; many everyday activities can be carried out more intelligently and with greater safety because relationships to the laws of physical science are discerned. The nurse who has never learned to apply the knowledge of chemistry in her daily work little realizes how much she is missing. The claim of chemistry to an important place in the nursing curriculum can be better appreciated when some of its interrelationships to other parts of the program are considered.

Chemistry in relation to physiology. Many physiological processes are chemical in nature. The study of physiology must, of necessity, be superficial unless the student brings to it a knowledge both of the principles of chemistry and of the characteristics and behavior of substances, inorganic and organic, which function in reactions of physiological importance. A few examples will serve to illustrate this point. *Digestion* involves chemical reactions whereby substances capable of absorption and transmission to the cells are made from nonabsorbable materials provided by the food on the plate. The *production of energy* within cells, a characteristic of the living organism, is the result of a system of reactions for the maintenance of which the provision of oxygen is essential. To a considerable extent, the *exchange of oxygen and carbon dioxide,* both at the cells and at the lungs, is regulated through chemical reactions. The *buffering of acids and bases,* which operates continuously in blood, lymph, and cells, thus helping to keep the reaction of the environment within the narrow limits consistent with life and health, is maintained through a system of chemical reactions. The selective *elimination at the kidneys* involves chemical as well as physical processes. Understanding of the *functioning of enzymes and hormones* requires a knowledge of the action of catalysts. It follows that the nurse's understanding of the functioning of the normal body, as well as of the disturbances associated with disease and of the rationale of nursing care, is decidedly limited by an inadequate foundation in chemistry.

Chemistry in relation to nutrition. Since nutritional habits and standards have a great deal to do with both maintenance of health and recovery from disease, diet frequently constitutes a major factor in nursing care. Consequently, the nurse should be prepared to make good use of the best that is known in the modern science of nutrition. Whether her concern is with the selection of food, its preservation, its preparation, or its utilization within the body, application of knowledge of the chemical principles concerned constitutes a major part in comprehending the science of nutrition. To cite the words of Henry C. Sherman, one of the country's best authorities on the relation of food to health:

> Among modern developments adding to our insight into the processes of life, enabling us to understand these processes better, and in some measure to control and improve them, one of the most

important now appears to be the recent growth of knowledge in the chemistry of food and nutrition.[7]

Chemistry in relation to microbiology. Study of microorganisms and their life activities involves much the same knowledge of chemistry as contributes to an understanding of metabolic processes of higher organisms, including man. Many of the tests which the student will make in the laboratory, while studying the behavior of various microbes, are based on knowledge of the chemical reactions characteristic of different organisms. Intelligent use of germicidal and bacteriostatic agents, to guard against the spread of infection, is based upon a knowledge of their chemical and physical properties, especially their effect on protein. The precautions employed in handling these agents, whether for the purpose of protecting equipment or, more importantly, safeguarding the individual against harmful effects that might result from such contacts, likewise depend upon the understanding of physical or chemical behavior. Recent developments in chemotherapy open up another field which can be explored with greater interest and understanding by the nurse with a knowledge of chemistry.

Chemistry in relation to pharmacology and therapeutics. The administration of drugs prescribed by the physician for therapeutic purposes constitutes one of the major responsibilities of the nurse. It is essential that she have authentic information regarding the preparations which she handles — their nature, mode of action, therapeutic effects, possible toxicology, as well as dosages and methods of administration. Although many drugs are still used on a more or less empirical basis, definite information regarding chemical composition, properties, and principles underlying their action is becoming increasingly available. A knowledge of chemistry frequently enables the nurse to care for and administer medicinal preparations with greater intelligence, and thereby increases the safety and comfort of the patient. Nor is it necessary that this knowledge be acquired through the tedious and uncertain method of rote memorization, since much of this information can be organized on a reasoning basis. What to the uninitiated may appear to be a large number of different drugs can often be systematized, through a study of chemical relationships, into a relatively small number of groups of related compounds, thus simplifying the study.

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[7] Henry C. Sherman, *Chemistry of Food and Nutrition,* 7th ed., New York, The Macmillan Company, 1946, p. 1.

Chemistry contributes to intelligent nursing care. In matters pertaining directly to nursing care, the nurse should function with the competence of a specialist. As a professional worker, she should not only work with a high degree of skill but should also be capable of explaining each procedure in terms of the scientific principles involved. It must be admitted that many skilled and successful nurses do give acceptable nursing care without benefit of much knowledge of science, but this does not mean that chemistry has little significant contribution to make to the more intelligent and more professionally satisfying practice of nursing. Probably not a day goes by in the life of a busy nurse when she would not find a knowledge of chemistry valuable in contributing to better understanding of the procedures which she carries out. It would enable her to answer many such questions as the following: Why is it desirable to remove mucous secretions from thermometers preliminary to their disinfection? What solutions can be expected to have a corrosive effect on metal instruments? Why must safeguards against fire be strictly observed around an oxygen tent?

Few have worked on hospital wards without encountering the nurse who sees little in the day's work save a series of routine procedures. Many factors contribute toward this unfortunate attitude, but some of the difficulty may well lie in the failure to develop the study of nursing along more scientific lines. The nurse who understands what she is doing is much more likely to be interested in her work than the one who labors in the dark.

The care of the diabetic patient may be cited as an example of a situation in which the nurse with a knowledge of chemistry can use it to gain insight denied the worker who is deficient in this respect. She is in a better position to appreciate that failure of cells to use glucose will produce widespread disturbances throughout the body as a whole — notably in muscle and nerve cells. She will understand the test which is generally used for detection of glucose in the urine. She will be better prepared to understand the interrelation between the metabolism of glucose and of fat, and the significance of this relation in planning the diet of the patient. The rationale underlying the treatment of diabetic acidosis will have more meaning for this nurse.

Or consider the nurse who is caring for a patient with gastric ulcer. What principles underly the selection of diet? How do the various antacids — some of them salts, some metal oxides, some hydroxides — function in the treatment of the patient? What are the advantages and disadvantages of each type of antacid? Which are most likely to give rise to a condition of alkalosis, the signs of which the nurse is expected to recognize and report to the physician?

The nurse who is caring for a patient in a fresh plaster of Paris cast knows that she must watch for signs of pressure and of restricted circulation. Why is this likely to happen? What is involved in the "setting" of the cast? Perhaps she has observed that the patient, swathed in moist bandages, is comfortably warm; how account for this? These and many other questions should constantly challenge the thinking nurse. And as she seeks for answers, her understanding of the science of nursing will surely grow.

These examples, cited almost at random, suggest only a few instances in which the intelligent study of chemistry rewards the student by increasing her understanding of her work, and consequently assures a greater interest on her part. Indeed, the clinical field is an area where systematic exploration on the part of interested nurses, with the necessary preparation in science, should uncover many yet unrecognized relationships between treatment and nursing care. This, in turn, should result in more intelligent co-operation between nurse and physician with resulting improvement in the quality of nursing care.

More general contributions of chemistry. Chemistry, when oriented to nursing, quite naturally leads to consideration of some problems which have broad social implications. Take, for example, the matter of industrial hazards; in many instances these arise from the use of some particular chemical or class of chemicals in the industry. It follows that both the cause and the necessary preventive measures are better appreciated when the nature of the substance is understood. Or consider the problem of the relation of fluorides in the water supply to the development of teeth; knowledge of chemistry contributes considerably to an understanding of this public health problem which is just now attracting a good deal of interest. Actually, as the study of chemistry progresses, a variety of opportunities occur for directing the attention of students to community problems, for calling attention to the social responsibility for protection of workers from contact with injurious chemicals, and for arousing interest in the part which a well-informed nurse should play in education of the public.

Another value that may come out of the study of chemistry is an interest in the history of the growth of knowledge relating to health and the conquest of disease. The story of Priestley's discovery of oxygen and Lavoisier's study of its relation to metabolism, the researches of the Curies with radioactive elements, the labors of Ehrlich to make his dream of chemotherapy a reality are part of the professional heritage of all those who work in the field of medical science. To appreciate the achievements of the past is to lay a foundation for more interested participation in the medical research which may be part of the experience of the modern nurse.

EVIDENCE OF INCREASING IMPORTANCE OF CHEMISTRY FOR NURSES

As has been emphasized previously, there is pertinent evidence pointing toward developments in medical science which the nurse will be able to comprehend only if she has a better knowledge of chemistry than is common today. Study of the history of progress in medical science led Bernhard J. Stern to make the following observation:

> There are variations in the importance of different discoveries and inventions in the field of medicine. The accumulation of knowledge is not gradual and continuous but is characterized by sudden spurts. Pending a particular discovery or one of a class of discoveries, further progress in a given field may be impossible. When the discovery is made and its meaning understood, developments follow rapidly as investigators apply themselves to cultivating its latent possibilities.[8]

Nurses are well aware of the stimulation afforded to medical science during the nineteenth century through the discoveries of Pasteur and Koch, from the introduction of antiseptic technic by Lister, and from the introduction of anesthetics by Morton and Simpson. From this train of discoveries came the development of modern surgery and progress in the control of communicable disease. The twentieth century has already been marked by notable discoveries in organic and physiological chemistry, accompanied by comparable advances in the field of medicine.

The most dramatic changes now in progress are in the development and use of chemotherapeutic agents. The basic concept that specific drugs might be discovered which would destroy pathogenic organisms with little or no deleterious effect upon the host was advanced by Ehrlich in 1910, but little progress was made at the time beyond the initial discovery of salvarsan for treatment of syphilis. The success which has attended the more recent discovery and use of the sulfonamides has reawakened interest in this field, and research in chemotherapy is now active. Some of the newly discovered drugs have already revolutionized the treatment, both therapeutic and preventive, of a variety of conditions, and this has been attended by radical changes in nursing care.

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[8] Bernhard J. Stern, *op. cit.*, p. 41.

Remarkable progress is also evident in the chemistry of vitamins and hormones, as well as in knowledge of proteins and their functioning. The very concept of disease due to deficiencies in essential substances, provided either through the food or as internal secretions, was unknown in medical practice of the preceding century. But modern developments in this area are coming almost faster than they can be assimilated. Nurses are well able to document this fact by reference to their own experience.

Early developments in physiological chemistry came slowly, owing in part to the relatively inaccessible areas within the animal body in which study and experimentation had to be carried on; but knowledge steadily accumulated.[9] With the recent discovery and isolation of less common isotopes of common elements, such as "heavy hydrogen" (or deuterium), and the achievement of artificial radioactive elements, new and fascinating tools have been put into the hands of the research chemist whereby he is able to acquire new insight into the metabolic processes within living cells.[10] The new knowledge resulting from these studies is even now finding application in medical research. Nurses who are working in hospitals where active research is in process find themselves participating in clinical situations where such studies are being carried on. Although such firsthand experience may be limited to special institutions, the results of significant research will bring changes in general medical practice and related changes in nursing.

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[9] Physiological chemistry is still a young science. The first laboratory for the study of physiological chemistry in America was opened in 1874 at Sheffield Scientific School, Yale University, by Russell H. Chittenden, then a young man 18 years of age. George R. Cowgill, "Russell Henry Chittenden," *Science*, Vol. 99, February 11, 1944, pp. 116–118.

Accompanying and contributing to the advance of medical science has come greater use of laboratory tests, many of them chemical in nature, both as aids in diagnosis and to mark the progress of disease. Although designed to afford information to the physician and actually carried out by specially trained technicians, these tests are also of interest to the nurse. When she understands their significance, the information provided thereby enables her to follow with greater comprehension the progress of the patient and his disease and this, in turn, adds to the interest of her work.

Although these changes have not occurred without affecting the curriculum of the school of nursing, critical observation of actual practice leaves ground for doubt as to whether the preparation afforded in chemistry is at all proportional to the increasing importance of this study in medical science. Insight into these newly developing phases of nursing does not come by magic. Without the background of knowledge which is essential for comprehension, the nurse will be quite unable to develop the degree of understanding which is one of the accepted marks of the professional worker.

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[10] Rudolph Schoenheimer and D. Rittenberg, "The Application of Isotopes to the Study of Intermediate Metabolism," *Science,* Vol. 87, Mar. 11, 1938, pp. 221–227; Rudolph Schoenheimer, *The Dynamic State of Body Constituents,* 2nd ed., Cambridge, Mass., Harvard University Press, 1946; Ernest Pollard and William L. Davidson, "Artificial Radioactivity in Practice," Chap. VIII, *Applied Nuclear Physics,* New York, John Wiley & Sons, Inc., 1942, pp. 146–168.

HISTORY OF THE DEVELOPMENT OF CHEMISTRY IN THE NURSING CURRICULUM

The course in chemistry which is now found in the curriculum of the American school of nursing has been in the process of evolution for about half a century.[11] Its general character is best understood in the light of the history of its development.

Early emphasis on the practical. One of the first facts to be borne in mind is that the early nursing schools were not founded primarily as educational institutions. Their chief concern was to provide nursing care for the sick in hospitals, and education of women in the art of nursing was a means to this end. In the pioneer schools, the establishment of a decent nursing service was in itself a tremendous and absorbing undertaking. Moreover, the schools were dependent upon the hospitals for support, and instruction was provided by busy nurses or co-operative physicians. It is not difficult to understand why, under these conditions, the practical took precedence over the theoretical in the early curriculums.

Chemistry enters the school of nursing. Records of the early training schools afford meager information as to their curriculums. Chemistry is mentioned in connection with occasional lectures on topics such as "Air: Chemistry of the Atmosphere"[12] and "Chemistry of Cookery."[13] Some incidental information may also have been gleaned in courses in hygiene, materia medica, and urinalysis. Evidence of what was perhaps the first organized presentation of the fundamentals of chemistry is found in the "explanatory lessons" which were given as an introduction to the study of foods and cookery at Johns Hopkins Training School. An outline of the content of instruction is found in *A Handbook of Invalid Cookery* published in 1893.[14] The topics included were: chemical and physical change, elements, air, fire, composition of the body, the five food principles (water, protein, fats, carbohydrates, and mineral matter), milk, digestion, and nutrition. Instruction in chemistry must have been meager at best in the pioneer schools since the time indicated for this study was usually from 1 to 3 hours.[15]

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[11] Lectures in chemistry as well as in anatomy and physiology were included in the program of studies in the pioneer school of nursing established by Florence Nightingale at St. Thomas Hospital in London, England, in 1860. Isabel M. Stewart, *op. cit.*, p. 63.

[12] Listed among the lectures at the training school of the Pennsylvania Hospital in 1893 to 1894. Quoted in Lydia Blaser, "A History of the Founding and Early Development of the Pennsylvania Hospital School of Nursing from the Year 1883 to 1908" (unpublished manuscript).

[13] The Boston Training School included instruction in cookery in its curriculum as early as 1876. A lecture on "the chemistry of cookery" is mentioned in connection with this course. See Isabel M. Stewart, *op. cit.*, p. 101. The First Annual Report of the Farrand Training School for Nurses, covering the years 1887 to 1889, mentions three hours of instruction in "chemistry of cookery." See Agnes K. G. Deans and Anne L. Austin, *History of the Farrand Training School for Nurses*, Detroit, Alumnae Association of the Farrand Training School for Nurses, 1936, p. 42.

Chemistry in the early preparatory courses. The development of preparatory courses to precede the clinical experience resulted in more systematic provision for instruction in science. This plan of instruction, introduced in this country in 1901 at Johns Hopkins Training School,[16] soon spread among the more progressive schools. In some instances the courses were conducted by the hospital schools themselves, in other instances through association with some technical school or college. That instruction in chemistry was sometimes but not invariably included in such courses is evident from two reports prepared by M. Adelaide Nutting and published by the United States Bureau of Education.[17] The report for 1906 mentions that courses in chemistry were given in a few schools. The report of 1912 indicates that, out of 72 schools reported, 11 included courses in chemistry in their curriculums. The following statement, in this report, called attention to the need for more general provision for instruction in this science:

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[14] Mary A. Boland, *A Handbook of Invalid Cookery for the Use of Nurses in Training Schools, Nurses in Private Practice, and Others Who Care for the Sick,* New York, Century Company, 1893. This text was undoubtedly in advance of current practice. It included suggestions for demonstrations or individual laboratory work in chemistry to accompany the lectures.

[15] The recommendations found in the "Report of the Committee on a Uniform Curriculum for Training Schools," *Third Annual Proceedings of the American Society of Superintendents of Training Schools for Nurses,* 1896, pp. 10–17, make no mention of chemistry. It is not included in the descriptions of curriculums of "Hospitals Reporting Three Year Courses," *Seventh Annual Proceedings,* 1900, pp. 38–96.

[16] M. Adelaide Nutting, "The Education of Nurses," *Ninth Annual Proceedings of the American Society of Superintendents of Training Schools for Nurses,* 1902, pp. 15–22.

> But this more thorough work in foods should be preceded by at least an elementary course in chemistry, and this is equally needed as a basis for any satisfactory work in hygiene and sanitation or in materia medica. In some of the training schools connected with universities, it is noted that courses in chemistry are given, but these are few in number.[18]

Chemistry in the National League of Nursing Education Curriculum Study of 1917. Out of the experience with preparatory courses the practice developed in the more progressive schools of using the early months of the training as an educational period with much of the time devoted to formal instruction. But throughout the large majority of schools there was a general lack of uniformity in the education afforded the students; each school was very much a law unto itself in matters relating to its curriculum. The prevailing situation as to classroom instruction is suggested by the following:

> In all schools of which we have knowledge more than nine-tenths of the student's time throughout the three years [is] being devoted to practical work. This means that theory, essential and indispensable as it is, in reality occupies everywhere a relatively small place in respect to time in the curriculum.[19]

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[17] M. Adelaide Nutting, "The Education and Professional Position of Nurses," *Report of the United States Commissioner of Education*, Vol. 1, Washington, D.C., United States Bureau of Education, 1906, pp. 155–205; also *Educational Status of Nursing*, Bull. 7, Washington, D.C., United States Bureau of Education, 1912.

[18] *Ibid.*, p. 44.

[19] *A Standard Curriculum for Schools of Nursing*, Baltimore, Curriculum Committee, National League of Nursing Education, 1917, p. 9.

As a means for improving these conditions, the Education Committee of the National League of Nursing Education[20] undertook to outline a course of study to serve as a guide to schools of nursing, and to represent to the public a fair idea of what — under the existing system — was conceived to be "an acceptable training for the profession of nursing."[21] The work was begun in 1914 and was published in 1917.

The plan for theoretical instruction called for approximately 600 hours, of which the biological and physical sciences were allotted a total of 100 hours, an amount which was criticized by some as excessive.[22] The original plan proposed a combined course in chemistry and physics of 30 or 15 hours. When the *Standard Curriculum for Schools of Nursing* finally appeared, the course outlined was for 20 hours in "Applied Chemistry" and carried the suggestion that a good course in elementary chemistry should precede admission to the training school. The emphasis of the course outlined, both as to statement of objectives and as to treatment of content, provides evidence of the demand for the practical.[23]

Early textbooks emphasize the practical. Further evidence of this practically is found in the early textbooks which began to appear about this time. One of these, written by a nurse, carries the following statements in its introduction:

> For nurses to have a proper understanding of methods of cleaning, laundry work, cooking and diet is of infinite value both to the hospital and to the nurses. . . . To provide a foundation for such knowledge, by explaining the principles of the chemical and physical properties upon which the various actions that occur in cleaning, cooking, digestion, metabolism, etc., depend, was one reason for

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[20] In 1912 the name of the American Society of Superintendents of Training Schools for Nurses was changed to The National League of Nursing Education.

[21] *A Standard Curriculum for Schools of Nursing*, p. 5.

[22] "The Proposed Course of Study, Report of the Education Committee" (with discussion), *Twentieth Annual Proceedings of the National League of Nursing Education*, 1914, pp. 197–208.

[23] *A Standard Curriculum for Schools of Nursing*, pp. 51–54.

compiling this book. A second purpose was to explain important chemical and physical processes constantly referred to in physiology, materia medica, and other studies included in the school of nursing curriculum.[24]

Another, prepared by a physician, carried the following comment:

> The teaching of chemistry to nurses is a new thing, but the development of medicine has made it inevitable. Some knowledge of the fundamental conceptions of chemistry is as indispensable as anatomy in the modern treatment of disease. Indeed it puzzles one to understand how, in the past, without chemical instruction, nurses made any sense at all of what was taught them in materia medica, physiology, and diet cooking. . . . Chemistry to the nurse is an accessory study, — an aid to the understanding of other studies of undoubtedly greater practical importance.[25]

Chemistry in the school of twenty-five years ago. A further picture of the situation with relation to the teaching of chemistry schools of nursing is furnished by the report of the five-year study, *Nursing and Nursing Education in the United States*, published in 1923. Of the 23 better-than-average schools selected for this study, 19 included chemistry in their curriculums. Only two of these courses exceeded 40 hours in length; the median was 24 hours, and the minimum a course of 10 hours.[26] The following comments taken from this report suggest the prevailing condition in these schools:

> The undeniable weakness of this subject in the training schools is primarily due to two reasons: lack of adequate time, and the unstandardized and generally overcrowded character of the courses. In some cases incompetence and lack of vision on the part of the teacher is a contributory cause. . . .[27]

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[24] Amy E. Pope, *Physics and Chemistry for Nurses*, New York, G. P. Putnam's Sons, 1916, p. iii.

[25] Ruben Ottenberg, *Chemistry for Nurses*, New York, The Macmillan Company, 1914, pp. v, vi.

[26] Josephine Goldmark, *Report of the Committee on Nursing and Nursing Education in the United States*, New York, The Macmillan Company, 1923, p. 275.

[27] *Ibid.*, p. 277.

> The nurses' course in chemistry must be one of reasonable thoroughness. It cannot consist, as it often does now, of a few lectures and perhaps two or three demonstrations, if it is to give her a truly basic knowledge. Equipment is expensive and teachers are hard to find, but no training school should consider these reasons adequate for the retention of ridiculously brief, stereotyped courses in so important a field. . . .[28]
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> The need for thorough training in chemistry is perhaps less obvious than in other subjects. Yet it must be reiterated that with the development of the study of bacteriology, physiology, dietetics, and the action of drugs, a scientific knowledge of chemistry is the foundation of an intelligent understanding of these subjects also. That its importance is belittled, or but vaguely appreciated, could not be more conclusively proved than by the almost universal allotment of time absurdly inadequate for the proper teaching of the subject.[29]

Chemistry and more recent curriculum studies. The outlines of the chemistry courses as found in the *Standard Curriculum* of 1917 and in the revisions subsequently prepared by the National League of Nursing Education, serve as a fairly reliable index of the progress made, from decade to decade, in the teaching of chemistry in schools of nursing. The studies, of which these outlines form a part, were undertaken by the League as a means for encouraging higher standards and to offer suggestions to the schools rather than to induce conformity. Chemistry courses vary in many particulars from school to school; nevertheless there has been a decided tendency to look to the outlines in the League publications as a guide and general pattern. Whereas in some schools the chemistry courses may have reached a level superior to that suggested by these studies, the majority have either lagged behind or barely attained this standard.[30]

The revision of 1927 carries a statement, which suggests both the prevailing status of science in the nursing school and the recognition of need for improvement.

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[28] *Ibid.*, p. 255.

[29] *Ibid.*, p. 279.

[30] See p. 42 for discussion of current practice.

> In the old Curriculum the fundamental nursing sciences were very weak in comparison with other subjects. It will be generally agreed that science teaching loses half of its value unless it can be taught with demonstrations and with some individual laboratory work. We must either drop all idea of laboratory work or give more time to these subjects.[31]

In this revision, the time proposed for each of the science courses was increased. The recommendation for chemistry was a course of 45 hours with a further increase to 60 hours whenever possible. The new distribution of time was more favorable to consideration of the fundamental principles of the science, while the emphasis on household chemistry was less evident.[32] It is also noteworthy that the Committee on Education, which was responsible for the study, recommended that students who presented credentials for work beyond high school with evidence of satisfactory completion of courses in science comparable with those in the nursing curriculum "be exempt from compulsory attendance on these courses, but be required to take examinations with other students."[33]

In the second revision, published in 1937, the suggested allotment of time for the chemistry course was again increased. This time the recommendation was for 80 to 90 hours with the suggestion of a reduction to 60 or 72 hours for students presenting satisfactory evidence of completion of a college course in chemistry. The importance of having the course designed to meet the specific needs of the nurse was generally agreed upon, but, since the opinion was quite frequently encountered that the nurse's need is primarily for knowledge of organic and physiological chemistry, it was necessary to defend the inclusion of a reasonably thorough foundation of general chemistry as indispensable for studies which were accepted as being important.[34]

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[31] *A Curriculum for Schools of Nursing*, New York, Committee on Education, National League of Nursing Education, 1929, p. 13.

[32] *Ibid.*, pp. 76–82.

[33] *Ibid.*, p. 36.

The prevalent opinion that the course for nurses should be directed primarily toward the study of organic and physiological chemistry may well have had its origin in the emphasis which, from the beginning, has been placed on the importance of chemistry for applications to cookery, nutrition, physiology, and materia medica. It is suspected, however, that a traditional pattern of reasoning is being accepted, rather than a judgment arrived at on the basis of critical study. To make a really serviceable study of organic and physiological chemistry without first providing a good foundation in general chemistry is impossible. The assumption that such a plan is feasible betrays ignorance of the problem. It suggests that significant application of knowledge of chemistry in the study of nursing has yet to be developed in actual practice.

The influence of the preparation of teachers. The preparation of teachers has also influenced the development of the chemistry course in the school of nursing. The findings reported in the study of 23 schools of nursing in 1923 are typical of the conditions which existed at that time.[35] They are not untypical of the conditions which exist today. The 20 teachers of chemistry reported by the 19 schools which were providing instruction in this subject, included the following:

4	resident nurse instructors (one of these was the hospital dietitian)
3	resident physicians or interns
2	hospital pharmacists
1	hospital pathologist
3	instructors in co-operating medical colleges
3	instructors in affiliated college or university
4	high-school teachers

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[34] *A Curriculum Guide for Schools of Nursing*, New York, Committee on Curriculum, National League of Nursing Education, 1937, pp. 168–192.

[35] Josephine Goldmark, *op. cit.*, p. 275.

It will be observed that for a considerable proportion of these teachers, instruction in chemistry was an incidental function. The fact is that in many instances the only qualification which the school considered to be essential was some type of preparation in the subject, preferably of college level. For the physician, the pharmacist, and the dietitian, chemistry had been required in their professional preparation. For nurse instructors, courses completed in college or normal school prior to admission to the school of nursing were frequently accepted as satisfactory qualification. There were also nurses who, after graduation from the school of nursing, had prepared through advanced study to become teachers of science; this was the only group whose study had been specifically for the purpose of teaching science to students of nursing.

Physicians, pharmacists, and teachers of chemistry from college or secondary school had all been nurtured on the conventional college chemistry and, in addition, each brought to the course a bias originating from his professional background. These teachers, as a rule, were more or less thoroughly prepared in the science but lacked insight into the needs of the student of nursing. Faced with the demand for a brief, applied course, they usually gave lecture courses, either abbreviated and attenuated replicas of the college sequence, or applied courses which were more or less related to the interests of the students but deplorably deficient in the rudiments of chemistry.

Nurses who prepared to teach the sciences were, of necessity, generalists, since they were expected to teach a variety of subjects. And although their teaching often drew vitality from their insight into the professional experience and their recognition of relationships between chemistry and other parts of the nursing curriculum, they were usually handicapped because of their minimum preparation in the subject, and also by inadequate provision for the course, both as to time and facilities. Even today the nurse who teaches chemistry in the school of nursing must be prepared to teach other subjects as well; few schools of nursing are large enough to require a full-time teacher of chemistry. This is not necessarily an undesirable situation. A well-organized curriculum can provide a combination of courses whereby the teacher's preparation in chemistry functions to strengthen other parts of the curriculum and at the same time help the student to integrate the sciences within her nursing experience.

Such are some of the conditions which have contributed to shaping the course in applied chemistry which prevails in schools of nursing.

The interest in college chemistry. The possibility of using college courses for the foundation in science has been a matter for deliberation and experimentation since about 1900.[36] Between 1903 and 1910, a number of preparatory courses were developed in technical schools and colleges,[37] and chemistry is mentioned in connection with these courses. Most of the independent courses were short lived; some merged into the three year nursing programs which were developing about 1909. However, this experience confirmed the belief of some of the leaders in nursing that possibilities did exist in this area.

About 1913, the National League of Nursing Education made an active effort to attract more college women to the nursing profession. This raised the issue of credit for college preparation, and whether exemption should be granted to students whose records indicated the completion of science courses in college. There were marked differences in opinion, and even schools which granted some credit to college graduates differed in practice with relation to exemption from science courses.[38]

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[36] M. E. P. Davis and Others, "Preparatory Work for Nurses," *Ninth Annual Proceedings of the American Society of Superintendents of Training Schools for Nurses,* 1902, pp. 23–36; also see M. Adelaide Nutting, "The Education and Professional Position of Nurses."

[37] Isabel M. Stewart, *op. cit.*, pp. 171–172.

During the period from 1926 to 1934, the findings of the Committee on Grading Schools of Nursing once more directed attention to the inadequacy of the teaching of the sciences in schools of nursing.[39] A recommendation which was frequently made at this time was for recourse to the college for this instruction.[40] As a result, more and more schools of nursing explored the possibility of securing the co-operation of near-by colleges for instruction in science. The Committee on Grading Schools of Nursing strongly advocated the development of university schools of nursing which would depend on the college for teaching the biological and physical sciences. This gave added stimulation to the movement, already under way, for the combined general and professional curriculum under college auspices. The record of this development and some of its implications have been presented already.[41]

CURRENT PRACTICE WITH RESPECT TO CHEMISTRY IN THE BASIC CURRICULUM

At the present time, the majority of schools of nursing make some provision for chemistry in their programs, either through a course within the basic curriculum or by requiring chemistry as a prerequisite for admission. In most states, though not in all, some specific ruling is made with reference to the inclusion of chemistry in the program of an accredited school of nursing. In a few instances, this regulation appears in the law; more frequently it comes through the requirements for accreditation.

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[38] "Report of Committee on Approaching Women's Colleges," *Nineteenth Annual Proceedings of the National League of Nursing Education*, 1913, pp. 35–38; "Report of Collegiate Committee," *Twentieth Annual Proceedings of the National League of Nursing Education*, 1914, pp. 129–135; Elizabeth Burgess, "Admission Standards for Schools of Nursing" (with discussion), *ibid.*, pp. 141–165.

[39] *Nursing Schools Today and Tomorrow, Final Report of the Committee on the Grading of Nursing Schools*, New York, Committee on the Grading of Nursing Schools, 1934, pp. 166–172.

[40] Annie W. Goodrich, "The School of Nursing and the Future," *American Journal of Nursing*, Vol. 32, June, 1932, pp. 675–680; "A Diagnosis and Some Prescriptions," *Ibid.*, Vol. 34, July, 1934, pp. 666–668.

[41] See Chap. I, p. 9.

Length of course. From a study of the current announcements of 136 schools scattered throughout 31 states,[42] it appears that the commonest offering in chemistry is a course of 60 hours; next in frequency comes a 45-hour course; only three schools showed no indication of provision for this subject. Sixteen of these 136 schools appear to use college courses exclusively; some as prerequisite for admission, others through the inclusion of such a course in their own curriculums.[43]

Character of course. The standard three year curriculum is designed to prepare students for the general practice of nursing. Consequently, it is to be expected that chemistry courses within such curriculums will emphasize the applied phases of the study, and such is usually the case. The typical chemistry course in the three-year curriculum of the hospital school makes a selection from the fields of general, organic, and physiological chemistry. The emphasis on chemistry relating to foods and nutrition, which characterized the early courses, is still evident in the almost invariable specific mention of carbohydrates, fats, and proteins in the descriptions of such courses. The inclusion of blood chemistry and of urinalysis is also mentioned frequently. There is, however, almost no evidence that the study of physiological chemistry goes much beyond these traditionally accepted areas.

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[42] See Chart I, p. 44.

[43] Under the pressure for an accelerated program to meet the exigencies of war, there was curtailment of the science courses in many schools. Two plans proposed by the Committee on Nursing Education in Wartime, Bull. 3, March, 1943, suggested chemistry courses of 60 and 45 hours, respectively.

CHART I

The Chemistry Course in the 3-Year School of Nursing

136 schools included, 31 states represented*

Number of hours		Number of schools
In college	xxxxxxxxxxx	11†
100	x	1
95	x	1
90	xxx	3
85		0
80	xxxxxxxxxxxxx	13
75	xx	2
70	xxxxxx	6
65	xxxx	4
60	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	41
55	x	1
50	xxxxxxxx	8
45	xxxxxxxxxxxxxxxxxxxxx	21
40	x	1
35	x	1
30	xxx	3
Less than 30	x	1
None	xxx	3
Hours not specified	xxxxxxxxx	9
Prerequisite only ‡		
High school	x	1
College	xxxxx	5‡
	Total	136

16 out of these 136 schools of nursing depend upon college courses, exclusively, for their instruction in chemistry. Of these, 11 (†) include the chemistry course within their own curriculums, and 5 (‡) make it a prerequisite for admission, offering no courses in chemistry within their own curriculums.

44 out of these 136 schools specify high-school chemistry as prerequisite for admission, in addition to the course in the nursing curriculum.

45 out of these 136 schools recommend, but do not require, high-school chemistry in addition to the course in the nursing curriculum.

1 out of these 136 schools of nursing depends on high-school chemistry alone.

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* This information is taken from announcements of schools of nursing which provide specific information regarding their curriculum offerings.

The brevity of the usual course imposes serious limitations on the development of the content. Consequently, there is an attempt to study the admittedly important applied aspects with a rather superficial knowledge on the part of the students of the underlying facts and principles of chemistry. The study of organic compounds has been seriously curtailed in the effort to fit the course into the allotted time. As a result, the treatment of these compounds is often limited to descriptive material, while the relationships which exist between the various classes of organic compounds are neglected. This, in turn, hampers the ensuing study of physiological chemistry. Moreover, this practice favors memorization of isolated facts instead of the more serviceable use of generalizations in accounting for specific applications.

The academic level at which the courses are developed varies greatly from school to school, depending on such factors as the attitude of the school administration toward education in general — and chemistry in particular, the teaching facilities, the preparation of the teacher, and the preparation of the student group. It would seem evident that, inasmuch as this is education for a responsible profession and because the minimum standard for admission to an accredited school of nursing is the completion of high school, the academic level of the course should be not less than that of first-year college chemistry. This is frequently not the case. Evidence to support this statement can be gathered from the demand for simple and easy textbooks; few chemistry textbooks so far produced for use in schools of nursing are of college level. Further evidence is provided by the superficial character of test questions in actual use in chemistry courses. Moreover, the reactions of nurses themselves to the courses included in their basic preparation suggest that, as a rule, these individuals did not consider the chemistry courses in schools of nursing to be adequate.

But in spite of these evident weaknesses, there is good reason for the belief that the applied course is not without merit. Under the direction of interested and competent teachers who are alive to the significance of the course offerings in relation to the curriculum as a whole, students learn to organize this material in functional relationships. And, when chemistry begins to weave itself into the pattern of nursing experience, it is less likely to remain isolated and inert in the mind of the student than when it is studied in a setting quite apart from the work of the nurse. Another advantage not to be discounted is that, with both teacher and student in immediate contact with the nursing situation, motivation favorable to the desired learning is more readily provided.

Use of college chemistry in the three year curriculum. There is an evident trend toward the use of college chemistry in the three year curriculum as well as in the longer programs leading to degrees. Sometimes a course in college chemistry is made a prerequisite for admission, and no further provision is made for this subject in the professional curriculum; sometimes chemistry is included in a prenursing curriculum conducted by a college with which the school of nursing is associated; sometimes the college teaches the science as part of the curriculum of the nursing school.

When the prerequisite for admission simply specifies a course in college chemistry, or one year of college chemistry, it may safely be assumed that the majority of students will have had only inorganic or general chemistry. There is less uniformity among the courses in prenursing curriculums; but in many instances they will be found to be similar in most essentials to the introductory courses in college chemistry.[44] Frequently transfer of chemistry to the college has resulted in a longer course,[45] sometimes one which entitles the student to college credit. It should not be taken for granted, however, that this change always results in more adequate preparation of the student for nursing. When the study carries the student no further than the field of inorganic chemistry, the program must be considered deficient. Even when the college has made adjustments in the chemistry course to include selections from organic and physiological chemistry as well as the fundamental general chemistry, the course may still be poorly adapted to its function in the nursing curriculum. This is particularly likely to be the case when the design is left largely to the direction of the subject-matter specialist who may be quite at a loss to know what chemistry will really be most valuable to the nurse. It is no secret that there is considerable resistance on the part of teachers of college chemistry to any significant modifications of the conventional courses.[46] And unfortunately, the school of nursing has been far too readily disposed to accept the college offering without making its own critical evaluation in terms of its own needs; and this is in face of the fact that the conventional college chemistry course is designed with a primary interest in the future chemist — hence may be ill adapted to the decidedly different needs of the student in nursing.

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[44] George W. Graves, "The Junior College and Other Institutions of Collegiate Grade," *Forty-second Annual Proceedings of the National League of Nursing Education*, 1936, pp. 109–117.

Chemistry in schools of nursing with programs leading to degrees. The chemistry programs so far considered have been those in the three year curriculums which are frankly vocational in purpose and content. The university or col-

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[45] The query might be raised as to how the school of nursing, which has found it impossible to provide a course of more than 45 or 60 hours in chemistry within its own curriculum, becomes able to afford the time for 90 or more hours of chemistry when this instruction is transferred to the college.

[46] "Chemistry Instruction for Purposes of General Education," Report of A.A.A.S. Committee on the Improvement of Science Instruction for Purposes of General Education, *Journal of Chemical Education*, Vol. 18, January, 1941, pp. 10–15.

CHART II

Chemistry in Schools of Nursing with Programs Leading to Degrees

a study of 50 schools*

Description of courses	Number of schools	Total	Range of credit in points
General or inorganic chemistry — 1 semester	xxxxx	5	4– 6
General or inorganic chemistry — 1 year†	xxxxxxxxxxxxxx	14	8–12
General or inorganic — 1 year followed by organic chemistry — 1 year	xx	2	10
General or inorganic — 1 year followed by organic or biological chemistry — ½ year	xxx	3	15–20
General or inorganic, organic, and biological chemistry — 1 year (inc.)	xx	2	7–12
General or inorganic — 1 year followed by organic and biological chemistry — 1 year	xx	2	18–20
General or inorganic — 1 year followed by an applied course‡	xxxxx	5	12–20
General or inorganic chemistry — ½ year followed by an applied course§	xxxxxxxxx	9	6–15
Applied chemistry, only	xxxxxxx	7	4– 6
No chemistry specified	x	1	
	Total	50	

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* Information gathered by study of the current catalogues of both the school of nursing and the college with which it is associated.

† Two schools in this group include qualitative analysis.

‡ One school in this group required the college chemistry as a prerequisite and gives, within the nursing curriculum, an applied course of 110 hours.

§ One school in this group requires a college course as a prerequisite and gives, within the nursing curriculum, an applied course of 45 hours.

legiate school of nursing usually offers a combined general and professional program. In such a curriculum, it is almost a foregone conclusion that chemistry will be included in the preprofessional program. In this situation, there is justification for expansion of the offering in chemistry and its enrichment from the cultural standpoint; however, the study should also be planned in such a way as to provide for the professional needs of the student in nursing.

A study of the curriculums of 50 schools of nursing offering degree programs, undertaken for the purpose of discovering what provisions are made for teaching chemistry, reveals considerable variation both as to the amount of chemistry being required and as to the areas covered.[47]

The maximum requirement within this group of schools is found to be two years of college chemistry; the minimum, an applied course of 45 hours, with no chemistry prerequisite. There are also marked differences in the patterns followed in different institutions. That which appears with greatest frequency is a course in general chemistry, either a year or a single semester, with no indication of any provision for organic or biological chemistry; this seems to be the practice in 19 of the 50 schools. Next in frequency is general chemistry followed by an applied course, as indicated by 14 of the schools. Nine others describe various combinations of general chemistry with organic or biological chemistry, or both. Seven of these schools give an applied course only, which in no instance exceeds one semester in length. It is also noteworthy that the specification regarding general chemistry, in a number of these institutions, is simply for a year's course in college chemistry which may be taken at any accredited college or university.

The picture thus presented is one of great irregularity in practice. Without study of the courses in actual operation, no valid judgment can be formed as to how many of these schools of nursing have developed really good programs in chemistry. A college program involving 8, 10, 15, or more credits in chemistry appears large by comparison with the offering in the usual three year nursing curriculum. But this picture may be deceptive. When the study terminates with general chemistry, there is no doubt as to inadequacy. When this is supplemented by organic and biological chemistry, the program may or may not be actually meeting the students' needs. There is enough evidence of inadequacy in some of these programs, as represented by the 50 schools, to justify grave concern for the quality of the foundation in chemistry in some schools of nursing offering degree programs. Does this situation exist because the school of nursing has not given sufficient study to the needs of the students for whom it has assumed responsibility? Does it arise because nurses have accepted uncritically the claims of the college? Does it occur because a conservative concept of liberal arts philosophy prevailed over the professional in the development of the combined course? These questions merit thoughtful consideration by those who are interested in the education of nurses.

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[47] See Chart II, p. 48.

The prospect for use of college chemistry by schools of nursing. There is good reason to believe that the trend in schools of nursing is in the direction of closer association with colleges and universities, and that the courses in science, particularly in chemistry, will come more and more from the college. In some institutions, the conventional chemistry courses and sequences have acquired such prestige that it is virtually impossible to secure any significant modifications. Or, when modifications are conceded, the course is not accorded the same recognition which is granted the conventional course. This is a situation which the school of nursing must face in working out a combined program. If the decision must be between academic prestige and functional value, surely the latter is the major consideration.

The fact that schools of nursing have, not infrequently, found it possible to obtain modifications in the college program is evidence of willingness on the part of some colleges to co-operate in developing serviceable programs; hence, it is important for schools of nursing to be prepared to work with colleges in designing more functional courses in chemistry for the service of their students. The outlook for this development will be better when every school of nursing has on its own faculty nurses who are competent in chemistry as it relates to nursing, and who are in a better position than at present to act as interpreters in this area and to make intelligent and constructive criticisms of the program developed within the college.

OBJECTIVES OF THE PROGRAM IN CHEMISTRY WITHIN THE CURRICULUM OF THE SCHOOL OF NURSING

The objectives of the program in chemistry within the nursing curriculum are essentially the same whether the school depends solely upon the resources of its own curriculum or whether it relies, in part, upon the college for formal courses in chemistry. This does not preclude enlargement of the scope of these objectives when this instruction is provided in the program of general education. It does suggest, however, that the basic professional program should not be considered to be complete until provision has been made, either within the curriculum of the school of nursing itself or through a combination of college and professional courses, for attaining all of the objectives as they apply to nursing.

Statement of objectives. The major objectives which have been selected to direct the formation of the program of chemistry in this study are:

1. To provide a foundation in the facts and principles of chemistry which are most essential for intelligent practice of nursing. This should take into consideration (a) the

chemistry which contributes significantly to an understanding of the related sciences of physiology, microbiology, pharmacology, nutrition, and pathology; (b) various phases of chemistry which help the nurse to provide for the safety and comfort of the patient and for intelligent handling of equipment and supplies entrusted to her care.

2. To afford practice in the recognition of significant relationships which exist between chemistry and other parts of the nursing curriculum; and to establish the habit of using this knowledge of chemistry to attain greater understanding of the art of nursing.
3. To develop an understanding and appreciation of the methods of science as they find application in the care of the sick, the study of disease, and the promotion of both individual and community health.
4. To provide a foundation in chemistry which will enable the nurse to read with a reasonable degree of understanding the literature of medical science as it relates to nursing; thus favoring her continued growth.
5. To stimulate an understanding interest in the contributions which chemistry and outstanding chemists have made toward the development of modern civilization, especially as they relate to better care of the sick, the conquest of disease, and the improvement of health.

These objectives cannot be realized through reliance upon formal courses alone. The organized study of chemistry should provide the nucleus for subsequent growth and integration which should be fostered in many parts of the curriculum. One condition which, for most students, is important for full realization of these objectives is the support of a nursing faculty possessing a good knowledge of science and alert to the possibilities of using this knowledge in the many nursing situations where it has significant application.

Only as sound classroom instruction finds its fulfillment in a good quality of nursing will these objectives have been attained. When students and teachers, head nurses and supervisors habitually use their knowledge of science for evaluation of nursing practice and as a means for giving expert nursing care, a real advance will have been made in the evolution of nursing from the status of an empirical art to practice of professional level.

Chapter III

THE INTRODUCTORY COURSE IN COLLEGE CHEMISTRY — ITS CONTRIBUTION TO THE CURRICULUM IN NURSING

But the college should always keep in mind that it is the student who is there to learn, and that the education offered him ought to become an integral part of his life.

—Algo D. Henderson[1]

The idea of using college courses in chemistry as part of the foundation for the nursing curriculum has long found advocates among those concerned with the problems of nursing education. However, to a considerable extent, the excellence of the college offering has been taken for granted without serious attempt on the part of nurses to evaluate its functional value for the student of nursing. What contribution toward the program of nursing education can be expected from the introductory course in college chemistry? This is the question which is proposed for study.

The college offering in chemistry bears the imprint of the cultural setting in which it has developed; hence, a better understanding of its character and of the attitudes of college educators toward this part of the curriculum may be acquired if, preliminary to the study of the course as it appears in current use, a broader perspective is obtained through consideration of the intellectual setting and historical background of this subject.

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[1] Algo D. Henderson, *Vitalizing Liberal Education: a Study of the Liberal Arts Program*, New York, Harper & Brothers, 1944, p. 117.

ATTITUDES IN THE COLLEGE TOWARD SCIENCE WITHIN ITS CURRICULUM

The liberal arts tradition versus vocational interests. Traditionally, the world over, the college has been an aristocratic institution. Its primary interests have been intellectual and cultural rather than vocational. It has thought of its function as that of providing discipline for the minds of able students; of transmitting the cultural heritage from generation to generation, of preparing the student to live richly, quite apart from vocational interests. The American college operates, however, in a country where it is assumed that equal opportunity shall be provided for all, and where it is expected that every man will eventually earn his own living; consequently the demand for professional preparation has had a powerful influence on the college curriculum. The college has been subjected to conflict between the conservatives, who seek to preserve the purely academic liberal arts tradition; and the progressives, who urge that real vocational interest is a stimulating force not to be ignored, and that the combination of liberal and vocational interests in education not only gives vitality to the college program but is a natural development when the important place which vocation occupies in the pattern of living is recognized.[2]

The traditional concept of liberal education has many supporters and is deeply entrenched in the minds of many, perhaps the majority, of the college educators.[3] Nonetheless, although the conservative element would gladly see all technical and specialized education confined to technical institutes and professional schools, the fact is that some degree of vocational preparation is a recognized function of most colleges.[4] The attitude of the college toward chemistry within its curriculum cannot be understood without taking into consideration the conflicting viewpoints which exist regarding vocational education.

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[2] Walter C. Eells, "Developments in Higher Education — Wise and Otherwise," *Journal of the American Association of Collegiate Registrars*, Vol. 17, July, 1942, pp. 445–492; also see Algo D. Henderson *op. cit.*, pp. 49–50.

[3] Attitudes and points of view of many eminent college educators, past and present, are presented by R. Freeman Butts in *The College Charts Its Course: Historical Conceptions and Current Proposals*, New York, McGraw-Hill Book Company, Inc., 1939, see especially Chapts. XII and XIX.

One of the major demands for science in the college curriculum is in relation to vocational needs. However, many college educators deplore this motive for the study on the ground that it is not consistent with the philosophy of liberal education. They believe that the college should concern itself with the intellectual contribution of the sciences rather than with their utilitarian aspects. They advocate the development of courses which will focus the attention of the student upon the broad principles and great theories of the science, leaving the applications to frankly vocational courses. They value the laboratory as a place where the student becomes acquainted with the method of science rather than as a place which affords opportunities for developing technical skills. To quote from the writings of a contemporary college educator:

> Youth has a right to presume that a liberal education will introduce it to the great ideas and abiding values in the world of science. To assume that the only purpose science serves is utilitarian is to prostitute the idealism and the sacrifice that have always inspired scientists in their search for truth and in services to their fellow men. . . . Youth has also the right to be educated in the significance of the scientific method as an instrument of trained intelligence. In brief, the purpose of the study of science is to educate youth to be informed, skilled, and cultured in a world which science interprets and to provide it with a logical method to discipline and direct the intellect. [Applied science with vocational interests primarily

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[4] Alvin C. Eurich and Jas. A. McCain, "Programs of Vocational Colleges," *Forty-second Yearbook of the National Society for Study of Education*, Part I, Bloomington, Ill., 1943, pp. 435–449; also see R. Freeman Butts, *op. cit.*, p. 370.

in mind is characterized as utilitarian, and as such foreign to the college.][5]

The attitude which idealizes the intellectual contribution of science but disparages the introduction of practical interests reflects a point of view which has long been fostered in colleges and universities. This attitude has its roots in the ancient concept of the superiority of mind over matter, of ideas over material. It frequently appears as a reaction against practices which the conservative educator regards as detrimental to the best interests of the student. Adherents to this philosophy often idealize the value of "pure science" in the program of general education, and offer objections to the development of courses in "applied science" within the college curriculum. They charge that the knowledge acquired in "applied" courses tends to be superficial or narrow, and that absorption with skills and techniques prevents students from acquiring real understanding of the science.

Educators who accept vocational preparation as a part of the larger program of general education are more sympathetic toward the development of practical studies within the college. They recognize the necessity for such special preparation and the desirability that, for many students, vocational education should accompany education for personal development and citizenship. They maintain that the combination of cultural and vocational elements is preferable to divorce of general education from technical preparation.[6]

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[5] Stewart G. Cole, *Liberal Education in a Democracy: a Charter for the American College*, New York, Harper & Brothers, 1940, pp. 78 f, p. 92. Also see Henry M. Wriston, *The Nature of a Liberal College*, Appleton, Wis., Lawrence College Press, 1937; Robert M. Hutchins, *The Higher Learning in America*, New Haven, Yale University Press, 1936.

[6] A discussion of this problem is found in Paul H. Buck and others, *General Education in a Free Society: Report of the Harvard Committee*, Committee on the Objectives of a General Education in a Free Society, Cambridge, Massachusetts, Harvard University Press, 1945, pp. 51–58. This committee stresses the point that: "The problem is how to save general education and its values within a system where specialization is necessary." p. 53. [Reprinted by permission of the publishers.]

In actual practice the real issue is less that of the relative value of "pure science" versus "applied science" than of the interests which should direct the applications. Underlying any sound program of applied science there must be a foundation of basic principles. And, for many students, the study of science acquires deeper meaning and becomes a real intellectual challenge when they discover that a knowledge of scientific principles actually can be effectively applied in what they consider to be important areas of living.

The attitude toward the vocational course. Although science courses in the college are usually included in the student's program to serve vocational ends, courses which are frankly designed to meet the needs of specific professional groups have not developed to any marked degree in the first two years of the college curriculum. There is considerable evidence of opposition within the college to any significant modification of the type of course offered or to departure from the established sequence of courses. Consequently, the demands made by various professional groups are criticized as, in the long run, shortsighted policies. The following is a typical criticism.

> Impatience with theory appears even in the teaching of science. Students are hurried over the basic courses toward industrial chemistry, radio physics, or aeronautics. The fundamentals are scamped for premedics; the hard parts are softened for those interested in domestic science. In the haste to prepare students for "new" fields, in order to give them something "useful," they are often deprived of the genuine disciplines of science. Without that fundamental experience, they have inadequate foundations for further development. . . . The moment a course is drawn into false proportions by presumed vocational values, there is an accompanying tendency for the student to concentrate his attention on the techniques which seem "practical," and to close his mind to ideas which are "theoretical." Vocational enthusiasm as a motive, therefore, is often a two-edged sword, for it sometimes cuts off the person with a fixed ambition from a larger conception of life.[7]

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[7] Henry M. Wriston, *op. cit.*, p. 133 f, p. 169.

In many instances, the science sequence which has developed within the college is so inflexible that deviation through development of a course designed to serve the needs of some special group means that, should the student decide later to follow some other path of study, he may find that he is required to start with the first course in the college sequence in order to be admitted to any succeeding course. This is the situation that now exists with regard to the introductory course in college chemistry.

Some Influences Which Have Shaped College Courses in Chemistry

Although chemistry now holds a respected position in the college curriculum, this has not always been the case. The sciences had a hard and bitter fight before they were granted academic recognition, and some of the characteristics of the courses in the present curriculum are the results of adaptations which were made in order to survive in the college.

Early interest in chemistry in America, also in Europe, developed largely outside of the college. The first courses were found in medical schools. But it was pressure from without rather than interest on the part of the college itself which finally pushed chemistry into the liberal arts curriculum.

A demand for practical science. During the period directly following the American Revolution, there was evidence of considerable concern on the part of some of the founding fathers for a type of education which would be adapted to the needs of the new republic. There were some, Benjamin Franklin among them, who advocated cultivation of the applied arts and the study of science as a means for promoting the general welfare. Thomas Jefferson was interested in the teaching of science for furthering the development of agriculture. And with the growth of industrial interests, pressure began to be exerted on the colleges to provide preparation in science consistent with the needs of industry. To no small extent, the funds for the support of these sciences came from those interested in industrial developments. And this, in turn, influenced the course in the direction of preparation for positions open to chemists in industry.

During the nineteenth century, chemistry gained entrance to all of the outstanding American colleges and, consequently, soon made its appearance in other colleges as well. Two forces which contributed to this development were: (1) the demonstrated practical value of the science and (2) the enthusiasm of young scientists who were not only captivated by the thrill of practical discoveries but fascinated by a new intellectual experience.[8]

Opposition in the college to the admission of chemistry. In spite of the impression which chemistry was making on the public, it encountered a cool reception from the conservatives within the college. Frequently it was relegated to a minor place in the senior year, after the foundation in subjects considered to be of greater importance had been assured. It was accorded scant respect either by way of credits or academic standing.[9] In some institutions it developed not within the college proper but in associated technical institutes whose programs were not granted the same recognition as was given to liberal arts education.

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[8] "The age in which we live," wrote Benjamin Silliman, the pioneer professor of chemistry at Yale University, "is not less distinguished by a vigorous and successful cultivation of physical science, than by its numerous and important applications to the practical arts and to the common purposes of life. . . . The present period is distinguished by wonderful mental activity; it might indeed be denominated as the intellectual age of the world. At no former period has the mind of man been so directed at one time in so many and so useful researches." *American Journal of Science*, Vol. 1, 1818, p. 8; *ibid*, Vol. 3, 1821, p. 330. Quoted in Edward S. Dana and Others, *A Century of Science in America with Special Reference to the American Journal of Science, 1818–1918*, New Haven, Yale University Press, 1918, pp. 29, 289.

[9] Benjamin Silliman, "Deductive and Inductive Training," an address delivered before the Chemical Society of Lehigh University, 1872; also *Autobiography of Andrew D. White*, Vol. 1, New York, Century Company, 1904, p. 29.

The admission of chemistry was opposed *first*, on the ground of its utilitarian value, thus making it inappropriate for a liberal education, and *second*, on the ground that preoccupation with laboratory work was inconsistent with the ideals of mental discipline. Scientists countered these objections with the contention *first*, that the influence of the physical sciences on the culture was too significant to be ignored by the college, and *second*, that the rigor of the scientific method afforded mental discipline in no way inferior to that provided by the classics and by mathematics. It is interesting to notice that the arguments that were used by the conservatives to bar the entrance of chemistry to the college curriculum have a marked resemblance to the arguments which are now advanced by those who oppose any significant modifications of the existing courses and sequences in college chemistry.

Influence of the Morrill Act. The Morrill Act of 1862, which provided land grants for the support of colleges, "where all the needful science for the practical avocations of life shall be taught,"[10] functioned to increase the offerings in chemistry within the colleges. At the same time, passage of this bill wrought consternation among college educators who regarded this proposed practical type of education to be a threat to the accepted academic standards.[11] The reaction of the more conservative colleges was to give emphasis to the theoretical phases of the science and to turn their attention to the education of research specialists.[12]

Influence of the elective system. Then came the elective system. Indeed, the growth of the physical sciences, both in importance and in popularity, was in no small measure responsible for the pressure which finally broke down the hard and fast walls of the prescribed curriculum.[13] A natural outcome of the release from this academic restraint was expansion of the college offering in science, and a sequence of chemistry courses developed to which the course in general chemistry became the threshold of admission.[14]

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[10] Justin S. Morrill, quoted by Daniel C. Gilman, "Our National Schools of Science," *North American Review*, Vol. 105, Oct., 1867, p. 504.

[11] Daniel C. Gilman, *op. cit.*, pp. 495–520.

[12] Daniel C. Gilman, "On the Growth of American Colleges, and Their Present Tendency to Study Science," *The Papers Read Before the American Institute of Instruction*, Fitchburg, Mass., July 26, 1872, American Institute of Instruction, Boston, 1872, pp. 96–115.

Influence of the teachers of chemistry. The men who taught chemistry in the college also left their imprint on the subject. The first teachers were generalists, almost invariably medical men who taught more because of their interest in the new science and the possibilities it offered for advancement of human welfare than for the uncertain extrinsic rewards offered by the college. Then, about 1860, another type of teacher appeared. Young chemists, who had studied in the laboratories of the German universities, returned to the American colleges where they enthusiastically introduced the method of laboratory instruction and research. Soon the research chemist dominated the field not alone in the graduate school, where this development could be regarded as appropriate, but in the undergraduate program as well. In spite of the fact that the majority of students were interested in science for utilitarian purposes, scholarly research in pure science became the ideal in many institutions.

The adjustment of chemistry to the academic environment. Meanwhile chemistry was adjusting to the academic environment. Its advocates set up academic standards and were prepared to defend them against any charges of intellectual inferiority which its opponents might bring to bear.

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[13] Charles W. Eliot, "Inaugural Address as President of Harvard College," *Educational Reform: Essays and Addresses*, Boston, Century Company, 1898, pp. 1–40.

[14] Frank W. Clarke, *Instruction in Chemistry and Physics: Report on the Teaching of Chemistry and Physics in the United States*, Circulars of Information, No. 6, Washington, D.C., Bureau of Education, 1880, pp. 12–15.

"The struggle for rank may be said to have been won also," commented Alexander Smith, "but by a moral victory. The opponents are defeated but it may be doubted whether they are convinced."[15] Thus, in the course of time, chemistry came to occupy an accepted place in the college curriculum. But this recognition was not granted until the college had first exacted a considerable degree of conformity to traditional academic standards.

THE INTRODUCTORY COURSE IN COLLEGE CHEMISTRY

The present study deals particularly with the introductory course in general chemistry because most students, including those who subsequently enter schools of nursing, are required to take this course if chemistry forms part of their college program. Some of the outstanding characteristics of this course, in the undergraduate program of the American college, are traceable to the conflicting forces which, over the past 150 years, have influenced college offerings in science.

Student groups served by the general chemistry course. The enrollment in the introductory course in general chemistry is usually composed of students with a wide variety of interests. Students who expect to become specialists in some field of chemistry, preengineering students, premedical students, those interested in agriculture, home economics, and nursing, and students who have elected chemistry for purely cultural purposes may all be found in this course. The question may well be raised as to how the college course is modified to meet these diversified interests and needs. Actually, there is little evidence that the average college chemistry course has been significantly changed in order to provide for the varied interests of the student group. It is not unusual to find that all of these students are enrolled in the same course and put through the same paces.

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[15] Alexander Smith and Edwin H. Hall, *The Teaching of Chemistry and Physics in the Secondary School*, New York, Longmans, Green and Company, 1902, p. 21.

It is true that in some institutions an attempt at grouping is made — most frequently separation of those students for whom thorough preparation in the science is deemed necessary from those whose interests are more general. In some instances, the segregation of groups is in relation to specific vocational interests. Hendricks notes, in this connection, that professional schools are making a serious effort to have chemistry taught in such a way as to contribute to the professional success of the student rather than directed toward attainment in pure science, and that such schools are inclined to regard this plan of segregation with favor. However, in his opinion, teachers of chemistry, in general, would not approve a system which made such differentiation.[16]

A study made by Noll in 1932 at the University of Minnesota shows that although six sections in general chemistry had been organized, ostensibly to meet the needs of students with varied interests, essentially the same course was given in each section. Moreover, he made the observation that the university studied was not unique in this respect.[17]

For a large proportion of the students, the general chemistry course serves as a basis for other sciences to be included in a professional course; for a limited number it is the first step toward specialization in chemistry. To many students it is simply a prerequisite which must be completed before some desired vocational goal can be attained. Thus, the interests of the students appear to be focused on vocational needs. But what are the objectives of the course in the minds of the teachers of chemistry?

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[16] B. Clifford Hendricks, "Varied Objectives in Service Courses in General Chemistry," *Journal of Chemical Education*, Vol. 19, June, 1942, pp. 265–266.

[17] Victor H. Noll, "Science Teaching on the College Level," *Thirty-first Yearbook of the National Society for the Study of Education*, Part I, Bloomington, Ill., Public School Publishing Company, 1932, pp. 305–324.

Objectives of general college chemistry. It should not be expected that all teachers of college chemistry will subscribe to the same set of objectives. Nevertheless, responses made to various studies, as well as statements of objectives and purposes appearing in textbooks designed for use in introductory chemistry courses, indicate that there are several major objectives which are quite generally accepted.[18] Three objectives upon which the majority of teachers appear to agree are:

1. To provide a general appreciation and understanding of the development of the science of chemistry and its contributions to modern civilization.
2. To provide knowledge of the laws, principles, facts, and theories of the science of chemistry.
3. To provide for the development of scientific thinking through application of knowledge of scientific principles to problems encountered in the study of chemistry.

Other frequently encountered objectives are:

4. To provide an opportunity for the student to determine his aptitude for and interest in chemistry as a career.
5. To lay a foundation for later scientific work.
6. To afford mental discipline through development of habits of scientific thinking.

It is unusual to find the stated objective:

7. To afford opportunities for the student to practice the application of the principles and facts of chemistry for more intelligent solution of the immediate problems of daily living.

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[18] See Chart III, p. 66.

CHART III

Objectives in teaching general college chemistry — as reported in studies and expressed by teachers of chemistry	Studies I	II	III	Individuals 1	2	3	4	5	6	7	8
1. To provide a broad general appreciation and understanding of:											
a. Chemistry	X								x		
b. Chemical aspects of the universe			X								
c. Chemistry's place among the sciences		X	X								
d. Development of chemistry in relation to modern civilization		X	X	x	x	x	x			x	
e. Historical development of chemistry						x					
2. To provide for the development of scientific thinking through:											
a. Knowledge of laws, principles, and facts	X	X	X	x		x	x				x
b. Practice in generalization regarding scientific principles			X		x	x	x				
c. Application of scientific principles			X		x		x			x	x
d. Unspecified								x			
3. To provide for the development of specialists through opportunity to:											
a. Determine aptitudes and interest in chemistry as a vocation			X					x			
b. Lay a foundation for later scientific work					x					x	
c. Develop skill in manipulation and technique in laboratory work			X						x		
4. To provide intellectual discipline					x		x				
5. To help the nonmajor student to meet successfully problems relating to life	X										

Key: X — Objectives representing consensus of opinion among groups of chemistry teachers, as reported in studies
x — Objectives expressed by individual teachers of chemistry

REFERENCES

Studies:

I. Louis Heil, "Determining Objectives of Science Instruction in General Education," *Educational Record*, Vol. 23, January, 1942, pp. 94–105. A study made in 22 colleges or universities.

II. "Chemistry Instruction for Purposes of General Education," Report of A.A.A.S. Committee on the Improvement of Science Instruction for Purposes of General Education, *Journal of Chemical Education*, Vol. 18, January

There is evident in these objectives a decided inclination on the part of the teacher of chemistry to think of this course in terms of the future chemist. Thus the college, the very institution which deplores the tendency to early specialization, is fostering freshman courses in chemistry which are focused on the education of chemists with singular indifference to the interests of other students.[19]

Comparison of the objectives of the college course in general chemistry with those of the chemistry course in the curriculum of the school of nursing clearly indicates that these courses are designed to serve different purposes.[20] The former is intended as part of a program of general education, with a selective interest in students who may become chemists; the

1941, pp. 10–15. The responses of teachers of chemistry from 158 colleges and universities, 38 teachers colleges, and 15 professional colleges.

III. Otto M. Smith, "Accepted Objectives in Teaching General College Chemistry," *Journal of Chemical Education*, Vol. 12, April, 1935, pp. 180–183. Summary of the results of a questionnaire returned from 112 schools and 38 authors. A 66 per cent agreement was considered to be general agreement.

Individuals:

1. Victor H. Noll, *op. cit.*, pp. 305–342.
2. Stuart R. Brinkley, *Introduction to General Chemistry*, rev. ed., New York, The Macmillan Company, p. v.
3. Herman T. Briscoe, *General Chemistry for Colleges*, 3rd ed., Boston, Houghton Mifflin Company, 1943, p. iii.
4. Horace G. Deming and B. Clifford Hendricks, *Introductory College Chemistry; A Course for Beginners*, New York, John Wiley & Sons, Inc., 1942, pp. v, vii.
5. William C. Bray and Wendell M. Latimer, *A Course in General Chemistry*, New York, The Macmillan Company, 1942, p. i.
6. Harry N. Holmes, *General Chemistry*, 4th ed., New York, The Macmillan Company, 1941, p. vi.
7. Leon B. Richardson and Andrew J. Scarlett, *General College Chemistry*, New York, Henry Holt and Company, Inc., 1940, p. iv.
8. H. I. Schlesinger, *General Chemistry*, 3rd ed., New York, Longmans, Green and Company, 1938, p. 1.

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[19] "When a teacher discovers that 95 per cent of his students are not interested in chemistry for its own sake, but for what chemistry can do for his profession, he begins to understand the indifference of many of his students to the more technical phases of chemistry." B. Clifford Hendricks, *op. cit.*, p. 266.

[20] See Chart IV, p. 70–71.

latter is designed to meet the needs of a specific vocational group. In the college course, the primary interest is the study of chemistry as a science; in the nurses' course, study of the science is important because it is necessary for understanding other parts of the nursing curriculum. The objectives of the college course suggest no particular interest in the application of the science outside the problems which present themselves to the chemist; the objectives of the course in the nursing curriculum definitely direct attention to applications of chemistry in a wide range of situations encountered in nursing.

Even the objectives which both hold more or less in common, namely the acquisition of knowledge of chemistry, the development of scientific methods of attacking problems, and those related to the cultural contributions of the science, need not be attained through identical selection or treatment of content. Indeed, those who are interested in the possibility of fitting the introductory chemistry course from the college program into the nursing curriculum will do well to consider the disparity in objectives which marks the difference in emphasis of the two courses.

Criticism within the college of the teaching of chemistry. The teaching of the physical sciences, physics and chemistry, has not been immune to criticism within the college itself. Emphasis on the preparation of specialists, to the neglect of students whose interests in the study are more general, has not escaped the notice of educators interested in general education.[21] In 1940, the American Association for the Advancement of Science published the results of a study relating to instruction in chemistry at college level, in which 200 colleges participated. When teachers of chemistry were asked whether "the conventional course in college chemistry" is satisfactory for students who are not specializing in the science, more than half of this group answered that it is not. A decided resistance to change was evident, nevertheless, in the opinion expressed by the majority of these teachers that modification of the course tended to result in superficiality.[22] A discussion of the results of this study carried the following comment:

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[21] Paul H. Buck and others, *op. cit.*, pp. 220–222; also see *Report of the President of Columbia University*, 1930, p. 27, and W. A. Neilson, "Education Can't Be Better Than the Teachers," *Bulletin of the American Association of University Professors*, Vol. 25, December, 1939, pp. 590–591.

> There are those who depreciate any suggestions that the mode of presentation of the sciences should be changed to adapt them to the changing requirements of higher education. This attitude seems to be taken partly because the individual is not convinced *that the sciences have anything to gain by such a change* and partly through fear that academic standards will be jeopardized by such a change. . . . An amazing wall of resistance has been built up against experimentation in this field on the assumption that any such venture is necessarily in the direction of relaxation of intellectual standards.[23]

As a matter of fact, some of the modifications which teachers of chemistry have made in response to demands for courses to meet the needs of special groups have fallen into just this error and, consequently, these courses have not commanded the respect even of their originators. Too often, instead of making a serious study of the needs of the students a basis for redesigning the chemistry course, attempts have been made to satisfy the critics by simplifying the course — deleting the more difficult parts — with the result that the student has been presented with an attenuated model of the conventional course. Nowhere has this been more evident than in some of the courses which have been developed, reputedly, to meet the needs of students in nursing.[24]

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[22] "Chemistry Instruction for Purposes of General Education."

[23] Lloyd W. Taylor, "Science in General Education at College Level," *Science*, Vol. 91, June 14, 1940, pp. 562, 563 (Italics mine).

[24] George W. Graves, "The Junior College and Other Institutions of College Grade." *Forty-second Annual Proceedings of the National League of Nursing Education*, 1936, pp. 109–117. This article contains a criticism of science in prenursing curriculums.

CHART

Comparison of Objectives of the
Those of the

Objectives of the course in general college chemistry*
Appreciation To provide a general appreciation and understanding of the development of the science of chemistry and its contribution to modern civilization.
Knowledge To provide knowledge of the laws, principles, facts, and theories of chemistry.
Scientific Method To provide for the development of habits of scientific thinking through application of knowledge of scientific principles to problems encountered in the study of chemistry.
Vocational Guidance To provide an opportunity for the student to determine his aptitude for and interest in chemistry as a career. To lay a foundation for later scientific work.
Mental Discipline To afford mental discipline through development of habits of scientific thinking.

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* See Chap. III, p. 65. † See *A Curriculum Guide for Schools of Nursing*, 1937, p. 171.

IV

COLLEGE COURSE IN CHEMISTRY WITH SCHOOL OF NURSING

Objectives of chemistry in the nursing curriculum	
a as in curriculum guide†	b proposed for this course‡
Appreciation To become interested in and appreciative of the important place which chemical processes play in vital phenomena, also some of the important contributions which chemistry and eminent chemists have made to the development of modern civilization.	*Appreciation* To stimulate an understanding interest in the contributions which chemistry and outstanding chemists have made toward the development of modern civilization, especially as they relate to care of sick, conquest of disease, and improvement of health.
Knowledge To develop a body of chemical knowledge which will make possible a better understanding of related courses in physiology, microbiology, introduction to medical science, pharmacology and therapeutics, and the clinical subjects.	*Knowledge* To provide a foundation in the facts and principles of chemistry which are most essential for intelligent practice of nursing: (1) the chemistry which contributes significantly to an understanding of the related sciences of physiology, microbiology, pharmacology, nutrition, and pathology; (2) various phases of chemistry which help the nurse to provide for the safety and comfort of the patient and for intelligent handling of equipment and supplies.
Scientific Method To appreciate the difference between chemical facts and theoretical explanation of these facts in order to adjust intelligently to changing scientific concepts.	*Scientific Method* To develop an understanding and appreciation of the method of science as it finds application in the care of the sick, the study of disease, and the promotion of both individual and community health.
Specific Applications To learn to apply the principles of chemistry in the nursing care of the sick in order to work with greater intelligence, safety, and resourcefulness.	*Specific Applications* To afford practice in the recognition of significant relationships which exist between chemistry and other parts of the nursing curriculum; and to establish the habit of using this knowledge of chemistry to attain greater understanding of the art of nursing.
Professional Growth To acquire that basic knowledge of chemistry which every nurse needs in order to more intelligently interpret the scientific literature relating to her professional work.	*Professional Growth* To provide a foundation in chemistry which will enable the student to read with a reasonable degree of understanding the literature of medical science as it relates to nursing; thus favoring continued growth.

New York, Committee on Curriculum, National League of Nursing Education,
‡ See Chap. II, p. 51.

The resistance to change evidenced on the part of so many teachers of chemistry does not seem to be wholly reasonable. To infer that significant changes in the conventional course would entail lowering of academic standards suggests an intellectual superiority among those specializing in the science over those who elect other interests. Such a premise is fallacious. To suggest that changes to meet the needs of specific groups would endanger the science appears to imply that there is greater value in pure science than in science applied to the problems of everyday life, or used as a means to better professional service. To assume that the development of courses to meet vocational needs must result in narrow technical courses indicates a lack either of information or of imagination on the part of the critic. Selection is unavoidable; it is in operation in the conventional course which focuses its attention upon the interests of one particular group, namely, the chemists. Is it a fair assumption that since the conventional pattern has proved to be satisfactory for the training of chemists it is therefore of unquestioned excellence for all students? The attempt to fit all students to exactly the same course recalls the tradition of the Procrustean bed and the unhappy fate of its victims.

In spite of evidence of dissatisfaction in some quarters, the type of chemistry course which exists in the college today has powerful advocates, and it appears to be a reasonable inference that the majority opinion is still on the conservative side. There are current suggestions that the postwar period may bring with it a greater emphasis on courses designed to prepare for vocational experience. On the other hand, attention is being called to the interruption of the preparation of young scientists, occasioned by the exigencies of war, and the need for re-establishment of this program. This suggests that, for a time, it may be very difficult to enlist the interest of teachers of college chemistry in courses not designed primarily for the selection and preparation of chemists.

CONTENT OF THE INTRODUCTORY COURSE IN COLLEGE CHEMISTRY

In the course of its development, the introductory course in college chemistry has taken on a rather characteristic pattern. By the early part of the present century, a high degree of uniformity had developed, and there is reason to believe that this standardization still persists.[25, 26]

Evidences of standardization. Evidence of a considerable degree of uniformity as to content is provided by the following facts:

1. References to "the conventional introductory course in college chemistry," "the first-year chemistry course," or "the traditional course" all suggest recognition of standardization.
2. The marked similarity of content which, despite differences of organization and emphasis, is characteristic of textbooks designed for use in these courses is noteworthy.
3. Catalogue descriptions of first-year college chemistry courses are more suggestive of similarities than of differences in content.
4. The development of standardized tests is a practice which is practical only when a fair degree of uniformity can be demonstrated to exist. Such tests are in use for these courses.

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[25] Louis Kahenberg, "The Teaching of Chemistry," *College Teaching* (Paul Klapper, ed.), Yonkers-on-Hudson, N. Y., World Book Company, 1920; also "Chemistry Instruction for Purposes of General Education."

[26] In this connection it has been of interest to the author to study chemistry textbooks which have been used in the college courses in general chemistry throughout the past century. It is amazing to find a pattern emerging as early as 1831, in a textbook published by Benjamin Silliman of Yale, which suggests the pattern prevailing today, namely, principles of the science interspersed with the study of nonmetal elements and some common metal elements and their compounds, leading to the study of organic compounds. This pattern can be traced continuously through the majority of college textbooks in this field.

These claims for standardization should not be interpreted as indicative of a belief that real differences do not exist from college to college, or that the content receives the same treatment at the hands of all teachers. The stamp which the teacher puts on the particular course for which he is responsible can make it significantly different from a course of similar name and general content in the hands of another teacher. However, underneath all the differences in emphasis, in organization, and in method of teaching, there is a common body of content which can be expected in most introductory courses in college chemistry.

Use as a prerequisite for the professional course. When it is proposed to design a course in chemistry for the curriculum of the school of nursing on the basis of the introductory course in college chemistry, it is assumed that all students who have successfully completed such a course have had a common core of experience in chemistry. In making this assumption, neither more nor less is taken for granted with reference to mastery of subject matter than is generally assumed when this course is accepted as prerequisite for some other course. Some students undoubtedly will have acquired a better foundation for advanced study than have others. The actual preparation of the students may be expected to show variations with relation to the ability of the student, his interest in or aptitude for science, the rigor of the course, and the particular emphasis which was given in the study.

A search for the common core of content. How discover the common core of experience which might be expected of students who have completed an introductory course in college chemistry? The method chosen in this instance was a study of the content of a group of textbooks in current use in such courses in American colleges. In selecting this method, the author assumes that in most cases the textbook content is a reliable index of the content of the course; that is, that the majority of chemistry teachers select textbooks that are relatively consistent with the courses which they propose to teach, and that the study of students is directed toward a knowledge of the content of these texts.

In choosing this method, it is recognized that most textbooks cover a wider range of topics than will actually be included in the course. There is little difficulty in recognizing that certain topics constitute a special interest on the part of some one author and should not be considered as common content. There are also certain studies which are frequently mentioned by the authors as elective and which can, therefore, be regarded as variable from course to course. These include some of the more advanced material dealing with theoretical concepts; detailed study of less common elements and their compounds; material relating to quantitative analysis, covered in some but not all of the texts; the study of organic compounds.

Textbooks selected for study. Ten college textbooks in general chemistry were selected for study. In making this selection, the purpose was to secure a group of texts which would be representative of those in general use in beginning courses in colleges. A number of teachers of chemistry who were familiar with the textbooks in use in colleges were asked to suggest what they considered to be a representative selection. There was evident agreement regarding most of the texts. In order to insure variety in selection and treatment of content, no two books by the same author were included. Of the ten books thus selected, four are designed for use in the more elementary college courses, and their inclusion has the effect of screening out some of the advanced theoretical and more technical material which students would be likely to encounter only in the more rigorous courses.

Method of study. The ten textbooks thus selected were first subjected to a detailed item analysis, by means of which each was compared with the other nine for determination of the extent to which they contained essentially common content. Inasmuch as this material was later to be compared with the content of the chemistry course outlined in the *Curriculum Guide for Schools of Nursing*,[27] it was organized under headings which are more or less consistent with the content of this course outline. In some instances, the phrasing of the latter was modified to facilitate comparison, but care was taken not to change the meaning. Topics covered in less than half of the college textbooks were eliminated from the outline unless they were related to the content of the nursing course and therefore suggested important topics not consistently covered by the college course.

The common core of content. As the study proceeded, it became clearly evident that, in spite of certain differences in organization and variations as to the thoroughness with which some topics were treated, there was a high degree of uniformity among these books in the selection of content. Of the ten textbooks studied, only one differed so strikingly in its treatment of material as to leave any real doubts as to whether it would provide the conventional background in chemistry. On the whole, the lack of conformity of one book out of ten is less remarkable than the similarities which are evident throughout the group as a whole.[28]

In general, the first half of the typical textbook is found to be concerned with establishing the fundamental laws and generalizations of the science. An introduction to atomic theory and the related developments, including the use of formulas and equations for expressing quantitative relationships, found early placement, although a few authors postponed this material until a substantial basis of factual information had been developed. However, *this content can be depended upon to constitute a part of the experience of any student* who has completed the first semester of such a course.[29] Studies of oxygen, of hydrogen, of the gases composing the atmosphere, and of water[30] are introduced early, usually interspersed with the consideration of fundamental laws and theories. *Familiarity with this material, also, can be expected of all students.*

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[27] See Chap. I, pp. 12 f, 18 f for discussion of plan of study.

[28] For a detailed comparison of these textbooks see Appendix, pp. 218–251.

The study of radioactivity and of atomic structure is usually located in the first part of the textbook and associated with the study of periodicity of the elements. These prepare the way for study of ionization and the modern concept of oxidation-reduction reactions. However, in some instances, radioactivity and atomic structures are found in the latter part of the text, suggesting that this study may be postponed until the second semester. At least an introduction to chemical equilibrium is found relatively early in each book, although there is a general tendency to delay the more comprehensive treatment of this topic for the latter part of the course. A similar situation exists in the treatment of oxidation-reduction reactions. It may be inferred from these observations that *most students may be expected to have had an introduction to these topics, but it should be anticipated that considerable variation as to the thoroughness of this experience will occur from student to student and from class to class.*

Following the development of fundamental concepts comes the systematic study of elements and their compounds, organized in general consistency with the periodic table. The pattern usually followed places the consideration of metal elements in the last half of the course. A great deal of this content is descriptive in character and provides encyclopedic information regarding a large number of substances. Associated with the study of elements and their compounds, certain industrial processes receive special and often detailed attention: for instance, the manufacture of sulfuric acid, and of nitrates; the treatment of hard water on an industrial scale; glass, cements, paints, photography, metallurgy, and alloys. None of the texts exclude this industrial content though they vary remarkably in the relative emphasis.

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[29] In some instances this material is treated in a mechanical fashion with little evidence of an attempt to help the student to understand the quantitative significance of chemical shorthand.

[30] Two of the textbooks treated the study of *water* only incidentally.

Some noteworthy differences. Differences in thoroughness of treatment vary from topic to topic and from text to text. Some of these have little or no bearing on the chemistry needed in nursing situations, hence make no significant difference in the development of the professional course; others are noteworthy because they are concerned with subjects which do relate directly to chemistry which the nurse should understand as a basis for her work. Particular attention will be called to the latter group.

Authors differ notably in their interest in the historical background of the science; in some instances this phase was practically eliminated from the textbook. There is also marked difference in the detail with which descriptive study of elements and compounds is developed. This material is naturally of considerable importance for the chemist, but for the nurse the treatment does not need to be as comprehensive as that presented in even the more elementary textbooks. Neither does the work of the nurse require the mastery of details of laboratory procedure and the understanding of methods associated with the introduction to qualitative analysis. Hence, variations in these areas will have little effect on the subsequent development of the professional course.

Variations in the treatment of the following topics are worthy of special comment because they bear directly on the development of the applied course.

Ionization and concepts of acid and base. The presentation of the theory of ionization in the introductory course has, for some years, been in a stage of transition. Certain of the assumptions of Arrhenius are giving way to concepts of more recent development, and the extent to which this transition has been accomplished varies from text to text. A similar state of transition is evident also with regard to the adoption of the Brönsted concept of acid and base; some authors having gone over completely to the newer idea while others give preference to the long-established basis for classification. This situation affects the study of ionic equilibrium, of hydrolysis of salts, and of the terminology used in explaining the *p*H relationship. All of these contribute to the study of physiological functioning of salts, hence must be considered in relation to the chemistry with which the student of nursing should be familiar. *If the student group shows variation as to the length of time which has elapsed since this chemistry was studied, or if they come from different colleges, there may be a noticeable lack of uniformity in preparation in these areas.*

The p*H of solutions.* The importance of the relative activity of hydrogen ions[31] and hydroxyl ions in solutions is receiving increasing attention in a variety of situations involved in study or in actual practice in nursing. Consequently, it is noteworthy that the methods used and principles underlying the measurement of such concentrations, as well as the significance of the *p*H notation for recording such measurements, receive variable treatment from text to text. In some instances, a good basis for understanding is developed by the author of the text; in others, the *p*H expression is presented in a purely mechanical manner. It is probable that *students who have had an introductory course in college chemistry will have encountered these expressions, but it is quite possible that there will be a considerable proportion who have a minimum, and perhaps only a mechanical, understanding of the chemistry underlying this frequently encountered expression.*

Energy transformations. The relationship of energy transformations to chemical change not only provides a necessary factor for understanding certain phases of metabolism and nutrition but also contributes to better comprehension of many chemical reactions encountered in everyday life. Some of the textbooks studied provide a consideration of this topic which should be reasonably servicable to the student; in other texts, it receives almost casual mention.

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[31] Or hydronium ions, to use the newer terminology.

Study of oxygen. In every instance the oxygen study leaves much to be desired. For nurses this study is particularly important because it relates both to the physiological functioning of oxygen and to recognition of fire hazards and fire prevention. Situations are frequently encountered in nursing in which safety of patients, of other workers, and of the nurse herself may depend on her ability to apply such knowledge intelligently. The vital functioning of oxygen is dismissed by some authors with the unexplained statement that "oxygen is essential to life." In other instances, attempts to elaborate this idea are productive of superficial and sometimes grossly inaccurate statements. The functioning of oxygen in such everyday concerns as burning, rusting of metals, and decay of organic material is subordinated to the more dramatic, though less frequently encountered, uses of commercial supplies of oxygen.[32] Every one of the textbooks gives some space to the phenomenon of spontaneous combustion, but less than half of them discuss the conditions that are essential to any burning reaction and the application of this knowledge in fire prevention or fire control. It appears to be a very human but none-the-less unfortunate habit to discount the importance of the commonplace in favor of less frequent but more spectacular occurrences; yet, intelligent living depends to no small degree upon understanding and applying knowledge in commonplace situations.

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[32] This is not intended to suggest that the study of uses of commercial supplies of oxygen is not profitable, or that it should not receive attention. Their use in therapeutic treatment makes it of special interest to the nurse; however, it is not to be expected that the general course will handle this particular use in the detail which it should receive in the professional course. A recognition of the revolutionary changes in modern civilization, which have been made possible by the availability of commercial supplies of oxygen, opens up an exceedingly interesting area which may well be explored because of its cultural implications. Even this outlook is not very well developed in most college textbooks.

Organic compounds and related studies. Some consideration of organic compounds occurs in each of the ten textbooks. To simply check this material, topic by topic, leaves the impression that most of the content usually considered of importance for the nurse has received attention. This idea is quickly dispelled, however, by a more careful study. Actually there is marked variation from text to text in selection of content, in thoroughness of treatment, in relative emphasis, and even in accuracy; the most extensive presentation represents no more than a superficial survey of this large field.[33] It seems to the reviewer that the purpose of the various authors in including this material is primarily to afford the student a glimpse into the importance of organic compounds in modern civilization. Certainly no more than this will be accomplished. The emphasis is decidedly on industrial interests and, in general, these topics are handled with greater understanding than the material dealing with foods and nutrition. The presentation of the latter suggests very strongly that the specialist is on unfamiliar ground.

In considering the possible contribution of the introductory course in college chemistry to the preparation of the student in nursing, the study of organic compounds has been disregarded for two reasons: (1) This study is not universally included in courses in general chemistry. (2) The treatment of this material is not sufficiently thorough to serve the needs of the nurse, nor is the selection of content and the emphasis consistent with her professional interests.

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[33] The number of pages devoted to this study ranged from 20 to 80, with half of the texts ranging between 45 and 55 pages. The typical content included the following: aliphatic and aromatic hydrocarbons, the petroleum industry, alcohols, aldehydes, ethers, acids, carbohydrates, fats and soaps, plastics, synthetic flavors, dyes, rubber, fuels and flames, and finally foods and nutrition — with the emphasis on vitamins.

Comparison with the course outlined for the school of nursing. When the content of the introductory college course is compared with that proposed for the curriculum of the school of nursing,[34] certain significant differences become evident.

The range. Overlapping between the two courses occurs over only a limited range, namely in relation to the fundamental principles of the science and certain portions dealing with the behavior of inorganic substances. The study of organic compounds, if included at all, is decidedly limited; the study of physiological chemistry does not constitute a part of the introductory course in college chemistry. By contrast, the course designed for the school of nursing selects its subject matter from all three areas. Of necessity, in gathering from so broad a range, the choice must be made with great care, and some content which the chemist considers to be essential for the understanding of chemistry as a science must be omitted from the applied course. Although the student who enters the school of nursing, having first successfully completed the college course, may be expected to have broader and more thorough knowledge of many phases of general chemistry than could be provided through the briefer applied course, she will only have begun to cover the material which must be included to meet her professional needs.

Some of the content of the general chemistry course, which falls outside the range suggested for the applied course, will be of undoubted value to the student in nursing. For example, the more thorough study given to physical chemistry can contribute to the study of physiology; some knowledge of alloys and of the processes of metal corrosion may find useful application in the care of equipment; still other content is of interest from the cultural standpoint, or may lead to better understanding of industries operating in the community. Nevertheless, there is in the conventional course a great deal of detailed descriptive chemistry which is of doubtful functional or cultural value for the nurse, and indeed for many other students whose interests are not specially directed toward chemistry.[35] On the other hand, a number of subjects pertaining to the field of general chemistry receive such variable treatment in the college course as to make supplementary instruction advisable in the course planned to meet the needs of the nurse.

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[34] *A Curriculum Guide for Schools of Nursing,* New York, Committee on Curriculum, National League of Nursing Education, 1937, pp. 168–192; also see Appendix, pp. 218–251.

The time element. One of the claims frequently made for the college course is that the student will achieve a more thorough knowledge of the science than is possible through the brief applied course. When the relative time allotments are considered, the basis for this assumption is evident. Compare the possibilities offered to the instructor in the school of nursing, even with the suggested maximum of 90 hours for the applied course selecting from the fields of inorganic, organic, and physiological chemistry, with that of the college instructor who has from 90 to 200 hours for instruction in general chemistry alone. And, in many instances the disparity in time is even greater. Small wonder that the interested teacher of chemistry in the school of nursing envies the college teacher this opportunity and becomes discouraged or resentful when it is proposed that the hours be reduced to 60, or perhaps to barely 45! If the school of nursing could find it possible to provide, within its own curriculum, time for the study of chemistry commensurate with that which usually is provided for a comparable body of content within the college program, it could develop a course upon which it might look with pride.

The organization. The college course aims to give a logical and systematic presentation of the facts and theories of the science of chemistry and to provide experience in the use of scientific method of study and reasoning. However, logical development does not mean that the same sequence is followed by all. The most striking example of conformity is seen in the common pattern set by the periodic table for the detailed study of the elements and their compounds.[36]

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[35] What reasonable answer could be given to the young student who asked why it was so important that she know about all of the compounds of sulfur?

The applied course which has been suggested for the school of nursing likewise claims to follow a logical pattern, but since the end in view differs from that of the college course, the pattern of organization also differs. In this setting, chemistry is studied for the contribution it can make to more intelligent professional work. To quote from the *Curriculum Guide*:

> The subject has been treated in a systematic way, starting with the chemistry which is part of every student's experience, and building on this the more technical facts and theories. An effort has been made to establish a working knowledge of principles and to apply them in situations in which they function.[37]

One point of difference in organization is that the course outlined for the curriculum of the school of nursing makes no attempt to study individual elements and their compounds. Instead, a considerable amount of material, which is thus treated in detail in the college course, has been organized under generalizations which summarize reactions to be anticipated as the result of certain types of contacts — notably those involving acids, bases, salts, and water. The functioning of this organization may be illustrated by reference to the treatment of reactions resulting from contacts of metals with acids. In the typical college text, the student encounters such contacts *first* as laboratory methods for the production of hydrogen; *later* as first one metal and then another is mentioned in relation to its reaction with acids, and *sometimes again* in connection with methods for making various salts. Not infrequently each contact is treated as a distinct incident and nowhere throughout the book is a general reaction expectation pointed out to the student.[38] In the applied course, the approach to this study might be somewhat as follows:

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[36] When it comes to the study of specific substances the typical organization of material is as follows: occurrence, preparation, properties, and uses — a logical organization from the standpoint of industrial interest.

[37] *A Curriculum Guide for Schools of Nursing*, p. 169.

1. In general, what reaction can be expected when a metal is brought in contact with an acid? Important exceptions involving contacts of common occurrence can then be called to the student's attention.
2. Where are such contacts encountered in everyday life?
3. Of what importance are these reactions, or lack of reaction, in relation to daily concerns?

When the student recognizes that such generalizations are valid only when they are based on laboratory experience, and that in addition to her own experience references are available for checking the generalization against actual experimental records, she has at her command a means for applying this knowledge in a variety of practical situations.

The use of applications. Another major difference between the two types of course under consideration lies in the attitude toward applications. None of the textbooks studied failed to suggest applications outside the range of laboratory experiences; however it is evident, from comments made by various authors, that this material is regarded as always of secondary importance. For example:

> [One author writes:] New applications of chemistry to practical problems have been included, but the primary objective has been

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[38] The reaction expectation can be stated simply as follows: Metals above hydrogen (in the electromotive series) react with acids to make hydrogen gas and a salt. Some teachers may prefer to formulate the generalization in terms of an oxidation-reduction reaction.

> at all times to make the book an introduction to the fundamental knowledge of chemistry.[39]
>
> [Another writes:] At appropriate places applications of chemistry to everyday life — reference to agriculture, industry, and medicine — are introduced to further the student's comprehension and motivation and his appreciation of the contributions of chemistry to his world.[40]
>
> [And yet another:] Although emphasis is placed on the principles of the science, industrial applications and processes are included to indicate the importance of chemistry in the modern world.[41]

Not infrequently the applications selected consist of little more than encyclopedic information as to specific substances and their uses — information which has not been organized to point out to the student the relationship between use and the underlying chemistry. To select an example of interest to the nurse: the following statements concerning mercuric chloride are commonly included. Mercuric chloride is used in dilute solution as a germicide. It is poisonous because of its attack on kidney cells. Egg albumen can be used as an antidote because it reacts with mercuric chloride to form an insoluble precipitate. It is left for the student to discover the common chemical behavior which relates these facts to one another; and experience shows that for many students they continue to be three unrelated facts.[42] It is questionable whether practical applications treated in this way excite much interest on the part of the student.

By contrast, the course in the school of nursing emphasizes the importance of applications. One of the chief values of the study of chemistry is considered to lie in the contribution which it makes to safer and more intelligent nursing practice. The functional value of chemistry depends upon the student's recognition of relationships that exist between the facts and principles of the science and her own work. Consequently, from the very beginning, the study is directed toward establishing habits of associating and using this knowledge in specific nursing situations. Indeed, one of the strengths of the course developed in relation to hospital experience lies just here, namely, that an exceptional opportunity is afforded to keep the knowledge of chemistry alive through continuous application. It would be a mistake to assume, however, that the average school of nursing is really making the most of this opportunity.

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[39] Herman T. Briscoe, *An Introduction to College Chemistry*, Boston, Houghton Mifflin Company, 1940, p. iv.

[40] Joseph A. Babor and Alexander Lehrman, *Introductory College Chemistry*, New York, The Thomas Y. Crowell Company, 1943, p. vi.

[41] Stuart R. Brinkley, *Principles of General Chemistry*, 3rd ed., New York, The Macmillan Company, 1941, p. vi.

[42] Why not relate these facts to the generalization that salts of heavy metals (including mercuric salts) react with proteins (wherever such contacts occur) to make insoluble compounds? The class can then consider the effect which this destructive reaction with proteins would have upon living cells — whether of microorganisms or of animal tissues.

There is no good reason why the faculty of a school of nursing should expect that a college course in general chemistry will function automatically to enable the student to discover the relationships between the science thus studied and her experience as a nurse. If teachers of nursing will keep in mind the following facts, they will not be misled in this respect.

1. The interest of the subject-matter specialist usually lies in the study of the science rather than in its applications.
2. The teacher of college chemistry rarely has had the type of experience which would enable him to make telling applications in medical science and nursing.
3. The college course serves students with a wide range of interests; specific emphasis is justifiable only on applications which concern the interests of a major portion of the student group.

CONCLUSION

The necessity for supplementing the college offering. The conventional course in college chemistry, even at its best, goes only part way toward meeting the requirements of the student in nursing. It may be expected to contribute knowledge of fundamental facts and theories of the science; to introduce the student to the study of inorganic substances; to acquaint her with a few of the methods and techniques used by the chemist; and, perchance, to contribute to the development of scientific habits of observing and reasoning. It will not provide the necessary foundation in organic or in physiological chemistry, and some of the content of general chemistry will need to be strengthened. Moreover, the responsibility for helping the student to acquire insight into the functioning of chemistry in the professional situation, and for integrating this academic material in the new setting, rests with the school of nursing.

The conclusion that the introductory course in college chemistry does not constitute, in itself, an adequate preparation in chemistry for the student in nursing will doubtless be protested by some nurse educators who would fain be rid of the problem of teaching chemistry within the nursing curriculum. To this reviewer, this conclusion is inescapable and one which should be faced frankly by any school of nursing which is now depending upon, or which is planning to use, college chemistry courses as a part of its professional program.

A worthwhile undertaking. The task of rounding out the chemistry program should not be left to chance. With the college chemistry as a basis, a chemistry course for the school of nursing should be designed with a dual purpose in mind: that of providing more completely for the specific needs of the nurse through extending the study into the fields of organic and physiological chemistry, and that of integrating the material gleaned from the preceding course with the new study. Opportunity is thus provided both for strengthening weak places in the earlier preparation and for developing new associations, thus bringing the general chemistry into better functional relationship for the student of nursing.

The college offering has been developed chiefly by men who have been keenly interested in the science of chemistry and in the initiation of promising students into this field of research. For the preparation of research chemists, the offering serves admirably; for many others, including students in nursing, it does not fill the bill. Nurse educators should be just as keenly interested in the preparation of better nurses as chemists have been in the preparation of better chemists. It remains for them to provide, within the curriculum of the school of nursing, a program in chemistry which will equip the nurse effectively for service in her particular field of specialization.

Chapter IV

PROPOSALS FOR A CHEMISTRY COURSE FOR THE SCHOOL OF NURSING — TO FOLLOW AN INTRODUCTORY COURSE IN COLLEGE CHEMISTRY

One does not really possess knowledge unless one is able to use it; ability to use comes with practice in using; and interest in turn grows with the mastery and utilization of knowledge.

—Seba Eldridge[1]

INTRODUCTION TO THE COURSE

An opportunity for a rich experience. The study of chemistry, with its many ramifications in daily life, offers the student of nursing an opportunity for a rich experience. As teacher and students explore together the relationships of chemistry and nursing, it should become evident to the learner that a knowledge of substances and their behavior, when understood and intelligently applied, can contribute materially to the comfort and safety of patients, and thus improve the quality of nursing service. Then, as the learner realizes the extent to which the response of the organism, in life and health, disease and death, follows the laws of chemistry, this subject, which she approached perhaps as a troublesome requirement, may develop into an enduring professional interest.

The school that operates within the hospital setting has some unusual advantages for this type of study. The new experiences of hospital life continually challenge the interest of the student and provide opportunities for her to use her knowledge of chemistry in real situations. Moreover, as she perceives that this study contributes to better understanding of nursing (hence to achievement of her chosen professional goal), motivation should be provided which is favorable to continued learning. Yet despite these favorable conditions, the sober reality is that a great many graduate nurses, as they look back on the chemistry that was taught in the school of nursing, characterize it as superficial and uninteresting.

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[1] Seba Eldridge, "The Liberal Arts College: A Diagnosis of Its Shortcomings," *Journal of Higher Education*, Vol. 14, October, 1943, p. 345.

There can be no doubt that part of the trouble lies in the brevity of the course; so much must be attempted in so little time. It is recommended, therefore, that the foundation provided by the introductory course in college chemistry should not be used to accelerate the program within the school of nursing, or to abbreviate an already overcrowded course, but to provide opportunity for more thorough and effective study with a decidedly professional slant.

The basis for developing the proposed course. The course in chemistry, which is herein proposed for students in nursing who have had college preparation, attempts to make constructive use of the foundation provided in the conventional college course in general chemistry. The analysis of the content of this course, presented in summary in the previous chapter,[2] provides the basis for deciding what constitutes the common core of general chemistry which can be depended upon in building the advanced course. It also indicates certain topics which should be reviewed or given different emphasis in meeting specific needs of students in nursing.

Following the general plan, which was presented in Chapter I, the chemistry course outlined in the *Curriculum Guide for Schools of Nursing* has been used to direct the content of the professional course. The author has attempted to use this outline in accordance with the purposes for which it was designed, namely, as a guide which might be studied critically, adapted to meet the requirements of a specific situation, and modified in order to provide more adequately for changing needs in nursing practice and to take into account new developments in chemistry.

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[2] See pp. 75–81.

The course objectives reviewed. The objectives used to direct the formulation of the chemistry course within the curriculum of the school of nursing have already been stated.[3] It will be recalled that they are focused particularly on the study of chemistry as a means *first,* for achieving a deeper understanding of nursing experience, resulting in safer, more intelligent, and more interested practice of nursing; and *second,* for acquiring a knowledge of chemistry which is requisite for continued study, as a means for professional growth. An additional objective is that of helping the student to see significant relationships between her previously acquired knowledge of chemistry and the more specialized study related to nursing, in order that she may be able to integrate the old experience with the new.

Attainment of these objectives will not be accomplished through the formal course alone. If the classroom experience provides a serviceable foundation in chemistry and stimulates a real interest in the systematic study of nursing situations for discovery of scientific principles which underlie nursing procedure, it will have served well. But only as this chemistry continues to be *used,* not only in the classroom but on the wards and wherever it contributes to intelligent practice, will these objectives be attained.

A course at college level. College students admitted to the school of nursing already will have demonstrated their ability to do work of collegiate grade. It should follow, therefore, that the academic standard of the chemistry course within the nursing curriculum should be consistent with this experience. If, instead, the course more nearly approximates the level of high-school work, it will be unlikely to challenge the interest of more mature and better-prepared students.

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[3] Chap. II, p. 51 f.

The outline of the course can suggest the academic level, but there are certain conditions within the school itself that must be provided to make possible attainment of the desired standard.

1. *Competent instructors must be provided.* For successful work, this type of course requires teachers who have good preparation in chemistry, familiarity with the other basic sciences of the nursing curriculum, and, in addition, an intimate knowledge of nursing. Consequently, the teacher preferably should be a nurse with both academic and professional preparation for this work. This statement is made advisedly and with recognition of the fact that there are, as yet, few instructors with all of the necessary preparation. But nurses can obtain the preparation in chemistry, whereas no other group can supply teachers who have the same insight into nursing experience or who can be expected to devote themselves so wholeheartedly to the education of nurses.

2. *There must be time for study.* Time is necessary for both student and teacher. The student is expected to learn to apply her knowledge of chemistry in complex situations; to do this requires reflective thinking and often a real hunt for needed information. The more mature student with a college background should be expected to show greater competence in reading and independent study than the girl fresh from high school. But, if these abilities are to be encouraged, time must be provided for the activities which keep them in use.

3. *Library facilities should be considered.* Up-to-date and authentic reference books are necessary, and suitable scientific and professional periodicals should be readily available for reading and study.

4. *Suitable facilities for individual laboratory work and provision for lecture-demonstration are essential.* The importance of this should not need to be emphasized. And actually, a well-equipped laboratory for this type of course is not the prohibitive luxury which some discussions of the facilities of college laboratories have suggested. Any first-class hospital school can afford a good chemistry laboratory.[4]

Placement of the course within the curriculum. In a well-organized nursing curriculum, no course can be considered in isolation. In determining its placement, the functional relationship which chemistry has with other courses should be considered. Since this study contributes importantly to the other sciences and subsequently to the study of clinical and preventive nursing, it should either precede or run concurrently with the courses which it serves. This calls for placement very early in the curriculum.

The relationships between chemistry, physiology, and microbiology are particularly important. Unless these are consciously planned, the chemistry which is essential for understanding the other sciences may be found lacking and the study limited accordingly. In this connection, the plan of building upon the foundation provided by the college chemistry course simplifies the problem of articulation with the other sciences because the study proceeds more quickly to consideration of physiological chemistry.

The experience of the students is another important consideration. When the applied course precedes the initial hospital experience, it is deprived of an important source of motivation. Students who have little real insight into nursing experience cannot be expected to grasp the pertinent applications of chemistry to nursing, much less analyze nursing situations intelligently. Even the limited contacts of the preclinical period in the hospital setting are valuable. The natural curiosity and interest of an alert student, in contact with actual nursing, supply many opportunities for helping her to establish the habit of relating chemistry to nursing.

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[4] The nurse's work is not directed toward analytical chemistry and it does not emphasize quantitative work, hence, the expensive precision apparatus necessary for such study is not required. Elimination of this one factor cuts down the cost of laboratory equipment tremendously. A comparison of costs for the equipment of other parts of the institution — the hospital laboratory, or even the kitchen — will reveal that the cost of setting up a good chemistry laboratory for this type of course is moderate. Once the initial expenditure has been met, maintenance makes surprisingly modest demands on the budget of the institution. In many schools, the latter cost is charged to the student in the form of a laboratory fee.

When these relationships are considered, it becomes evident that the course in applied chemistry belongs at the beginning of the preclinical period which, in the hospital school, coincides with the introduction to nursing experience. The hospital school has a natural advantage at this point over many of the schools with college affiliations. The latter are faced with a real problem if the curriculum is not planned in such a way that the first orientation of students to hospital experience precedes the completion of the chemistry sequence. A valuable opportunity for establishing pertinent relationships is lost and, when such is the case, the responsibility for teaching the student to apply her knowledge of chemistry in nursing passes on to the instructors in nursing arts and in the clinical subjects. Are they prepared to assume this responsibility?

The Content of the Course

Selection of content. As has been emphasized previously, to meet the needs of nurses, the content must be carefully chosen from general, organic, and physiological chemistry. These sources are rich in valuable content; hence, the temptation is to attempt too much. To select that which is of greatest importance and yet not to exceed the content which can be handled with satisfactory thoroughness within the stringent limitations imposed by the three-year nursing curriculum has long been a vexatious problem.

The outline for the chemistry course obtained in the *Curriculum Guide for Schools of Nursing* is the result of the concerted efforts of teachers of nurses to make just such a judicious selection. As has already been indicated, this content will be used as the basis for development of the course now under consideration.[5] The outline was not accepted for use without evaluation; nor could it be used without modification. No compilation of content, however well-formulated in the beginning, should be expected to continue to function for a thriving profession without modification to meet changing needs in nursing and advances in chemistry.

Criteria for evaluation of the content of the course. Both for study of the content of the *Curriculum Guide* and, subsequently, for considering new material for inclusion in the new course outline, the following criteria were used:

1. Does this material make an important contribution to the nurse's understanding of her work?
2. Is this material suitable for inclusion at the student's present level of experience, and is it likely to find quite immediate use?
3. Is this material indispensable for understanding other content which is directly related to nursing?
4. Is this material which one could not expect to be covered adequately either in the previous course in chemistry or in some other part of the nursing curriculum?
5. Is a special value attached to this item, either for interest or importance, which warrants its inclusion or recall, even though it may have been treated previously in the chemistry course or in some other part of the nursing curriculum?

The *Curriculum Guide* outline was also studied for shortages with the following questions in mind:

1. What areas merit expansion because they were receiving too superficial treatment?

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[5] Chap. I, p. 13.

2. What areas should now be revised in order to bring them up to date?
3. What material not included in this outline should now be recommended for inclusion either: (a) because of its increasing importance in nursing, or (b) because of new developments in chemistry?

Conclusions following evaluation of content. In general, the outline still suggests the chemistry of major importance for the student in nursing. There are areas in which the particulars of the content should now be revised to bring them up to date, but, except where there is overlapping with the college course, there are few items which could justifiably be omitted, and none of the major topics or units should be considered for elimination. However, the outline in the *Curriculum Guide* is designed to embrace essential content from three important areas in chemistry and, because the time which is allotted to this study, in view of other needs, is decidedly limited, certain rather important content is cut to bare minimum essentials. This abbreviated content should now be expanded and enriched in order that it may function to better advantage for the student in nursing.

The time factor. Any tendency to expand the course unduly is effectively curbed by time limitations. How much of the time of the three-year curriculum can reasonably be allotted to the chemistry course? Curriculum committees have hoped that, when a school of nursing found it possible to make a college course in chemistry prerequisite for the professional program, there might be a material reduction in the time required for the course within its own program. This hope might be realized were it not for the fact that chemistry has been included in the curriculums of most schools of nursing on only the barest minimum basis. Therefore, to simply curtail the existing course on the assumption that the content of general chemistry had been covered in college and that only organic and physiological chemistry must now be considered, and to lop off the time apportioned accordingly, would perpetuate the same superficial study which is adversely criticized at present.

Under the plan whereby all of the chemistry is taught in the professional curriculum, the time that is suggested for chemistry is from 80 to 90 hours.[6] Actually, the average school is offering a course of 60 or 72 hours.[7] Moreover, it is doubtful whether, under the present educational system, the maximum which has been recommended for the three-year curriculum can be increased. The school of nursing with the longer college program has the opportunity for a fuller development. Such a school might reasonably be expected to develop its professional course, following the course in general chemistry, on a semester basis.[8]

The outline, which constitutes part of this study,[9] has been developed for use in a course of from 60 to 90 hours. This minimum is in line with the present recommendation in the League study;[10] even so, a longer period would make possible a richer course. The progressive school with a well-developed program of clinical education will find that its students are better prepared for such study when the stronger foundation in chemistry has been provided. The optional units included in the following outline are suggested with the longer course in mind.

Changes in content considered. The study of organic compounds is in urgent need of expansion.[11] This study often presents difficulties to the beginner, especially before she has become accustomed to the use of structural formulas and the general plan of organization. Until these important relationships have been grasped, the bewildering array of compounds with unfamiliar formulas and equally strange names is often quite frustrating. But when enough time is available for her to become acquainted with the more important types of organic compounds, their structural relationships, and their expected behavior, the way is clear for the understanding study of organic[12] compounds of physiological importance and of compounds used medicinally.

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[6] *A Curriculum Guide for Schools of Nursing,* New York, Committee on Curriculum, National League of Nursing Education, 1937, p. 83.

[7] See Chap. II, p. 43, and the accompanying chart.

[8] This suggests a course which might carry four points of credit.

[9] See Part II.

[10] *A Curriculum Guide for Schools of Nursing,* p. 170.

[11] *Ibid,* Unit IX, "Introduction to Organic Chemistry and Some Important Classes of Organic Compounds," p. 182.

Critics who are unfamiliar with the use and function of structural formulas often raise the question as to whether a knowledge of these formulas is of importance for the nurse. They assume that these expressions are to be memorized; which is not the case. The study is justifiable because these formulas are, in fact, visual aids devised by the chemist to show significant relationships and to point to the characteristic chemical behavior of compounds. It is possible in this way to systematize and simplify the study of organic chemistry, and to follow on a reasoning basis the similar behavior of compounds which might otherwise appear to be unrelated. Moreover, these formulas and the associated nomenclature are so frequently encountered in scientific literature that the student who is not familiar with them is handicapped in her professional study and practice. It is improbable that many students will pick up the knowledge of these relationships without a teacher's guidance. The question is less one of inclusion or omission than of relative emphasis; the time which may reasonably be devoted to this particular study should be regulated by the length of the course.[13]

Cyclic and heterocyclic compounds merit more thorough treatment than that suggested by the outline in the *Curriculum Guide*. A great many compounds of special interest to the nurse occur in this group: amino acids, vitamins, enzymes, and hormones — all of which are of recognized importance. Many of the compounds used for therapeutic purposes — alkaloids, analgesics, phenols used as disinfectants, and the sulfanilamide derivatives — also belong in this classification. The nurse who is interested in keeping up with modern developments in pharmacology, as well as along other lines, will appreciate a more thorough treatment of these cyclic compounds.[14]

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[12] There are also many inorganic compounds of physiological importance.

[13] See Part II, Unit II, pp. 129–143.

The nurse's study of enzymes has, in the past, been directed almost exclusively to the reactions involved in digestion. This still provides a convenient field in which the student can make firsthand investigation. But the knowledge of enzymes and their functioning is increasing. They influence metabolic reactions in both animal and microbial cells. A more careful study of enzyme action is warranted.[15]

Within recent years, there has been considerable productive study of the metabolism of all three of the great food substances — carbohydrates, fats, and proteins. Some of the results of these studies are of outstanding significance. This calls for revisions in the unit dealing with reactions within living cells.[16]

The final unit, formerly suggested as optional, is concerned with the physiological functioning of salts. A great deal of important chemistry is tucked away in this unit — more than appears to be recognized. Were this material being used to advantage, there would be less demand for the conventional treatment of blood chemistry. Herein is found the outline for a study of buffer systems and the associated reactions whereby the circulatory, respiratory, and excretory systems function together to maintain the environment for cellular metabolism. Because of the contribution which this study can make to an understanding of the generalized response of the body as a whole to disturbances of local origin, this material merits greater prominence.[17] For understanding nursing, it is of equal importance with the study of the metabolism of glucose, fats, and proteins. And for this particular study, the conventional course in general chemistry will be found to have provided a very good foundation through the emphasis which it customarily gives to ionization and chemical equilibrium. These applications, however, will be quite unfamiliar to the college student.

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[14] See Part II, Unit IV, pp. 157–167.

[15] See Part II, Unit VII, p. 181.

[16] See Part II, Unit VIII, pp. 188–198.

Some debatable issues. Some topics usually included in a conventional course in physiological chemistry are not found in the chemistry outline in the *Curriculum Guide*, or they have been treated only incidentally. Of these, there has been a considerable demand for studies of the vitamins, blood chemistry, and urinalysis. In judging the merits of such demands, it is well to keep in mind that, unlike the typical college program which provides for a considerable degree of election, the school of nursing has a curriculum which, in a large measure, is prescribed. This makes it possible in the nursing curriculum to eliminate to some extent from the chemistry course material that will surely, and often more appropriately, find placement in other courses. The claims of these and other similar studies should be considered on the basis of whether an important contribution will be made through emphasis on chemical behavior. Chemistry should support rather than duplicate the study in other parts of the curriculum.

Should a study of vitamins be included in the chemistry course? The study of vitamins constitutes an important and indispensable part of the study of nutrition. The use of vitamin preparations will be considered in the course in pharmacology and therapeutics. Vitamins will be mentioned in various connections in the study of disease and nursing care. The importance of the study of vitamins is unquestioned; however, this topic will not be omitted from the program of the student of nursing if it does not receive special consideration as a unit in the chemistry course. As knowledge concerning the various vitamins has accumulated, it is recognized that some aspects of vitamin chemistry, not usually developed in other courses, might appropriately be included in the chemistry course and that such study would be both interesting and instructive to the nurse. Consequently, a short unit on vitamins which will augment the information gleaned in other courses has been organized; however, it is suggested as optional.[18] The school with a generous allotment of time for the chemistry course might include this unit and thereby enrich the course; the school which must plan for a shorter course may well leave the more inclusive study of vitamins to the course in nutrition.

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[17] See Part II, Units IX and X, pp. 199–211.

What about blood chemistry? Shall that be included in the chemistry course? Mere duplication of the study made in physiology is not justifiable, and study of blood chemistry apart from the functioning of blood within the living organism has little value for the nurse. However, in this instance, there is a real contribution to be made by the chemistry course; and recent studies of protein metabolism, also in connection with blood banks, have added new interest to study of blood. This course will not treat blood as an entity but as a medium through which conditions essential for cell metabolism are maintained. As such, it must be studied in relation to the functioning of other systems — notably the interaction of the respiratory, excretory, and circulatory systems.[19]

There are those who suggest that the study of urinalysis belongs in the chemistry course. This raises the issue of the relation of ward experience to the program of formal instruction. Most certainly the study of physiological chemistry provides the background for understanding the abnormalities which are characteristic of disease. However, until the student is really caring for patients, she lacks the experience which is necessary for insight into the relation of laboratory findings to the condition of the patient and to his nursing care. Differences of opinion exist as to the stage at which the chemistry relating to pathology should be introduced. The position of the writer is that, for the most part, this chemistry should be taught when the student is actually caring for patients rather than during the first few weeks of the nursing program. The study in the nursing curriculum called "*Introduction to Medical Science*"[20] provides one opportunity for linking the work of the science courses with the study of disease. Further opportunities are presented throughout the entire nursing experience.

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[18] See Part II, Unit VI, pp. 174–179.

[19] See Part II, Unit IX, p. 199.

For urinalysis and other common laboratory studies which are to be included in the program of the student in nursing, the following plan is suggested. During the chemistry course, urine will be studied as a *normal* excretion.[21] The student will use the customary laboratory tests for the recognition of its various normal components, but pathological findings and their significance will not be emphasized since the purpose is to become familiar with urine as a normal excretion. The chemistry course, in this way, provides the background against which the student will later project the picture of the abnormal; it also introduces the usual laboratory tests. On the other hand the "*Introduction to Medical Science*" should utilize this experience and carry the student on to consideration of abnormal findings and their meaning in terms of the patient's condition and consequent nursing care. Then, as she follows the use of urinalysis in connection with the care of the diabetic, the nephritic, and patients with other conditions, she should find that her knowledge in this area is being extended and is acquiring more specific meanings. Similar observations might be made concerning extension of the study of blood chemistry and of other laboratory tests.

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[20] In some schools of nursing the course is called "Pathology."

[21] See Part II, Unit VIII, p. 194.

The teacher of chemistry who is accustomed only to the conventional courses in organic and physiological chemistry will find much to criticize in the outline proposed. Topics have been omitted which are regarded as of primary importance for the preparation of chemists, physicians, and even hospital technicians. No apology is offered for these omissions. The nurse is not being educated as a chemist, much less as a physician; she does not do the technical work of the laboratory worker. Her need for chemistry and her use of chemistry is dictated by the nature of her work as a nurse. Moreover, the time for this study must be balanced against the demands of a wide variety of other studies equally important in the basic preparation. An attempt has been made to cut away extraneous material and to get down to the nucleus of chemistry which will be of greatest functional value for the student of nursing.

Organization of content. The greater emphasis of the course is naturally on organic and physiological chemistry, building upon the previous study of general chemistry. However, a brief review unit dealing with certain fundamentals, including reaction expectations, is suggested for opening the study.[22] This has a twofold purpose: review of important material learned previously, and introduction of the student to the use of this chemistry in situations such as she will encounter as a nurse.

The study of organic compounds naturally falls into the logical organization which is adapted to bringing out the relationships from one class of compounds to another. Indeed, if this natural relationship did not exist, the study of organic compounds would be an overwhelming task for any student. Meanwhile, as the course progresses, advantage will be taken from time to time of the natural opportunities which occur for integration of material from general chemistry with the new study. Thus, for example, in connection with the study of the chemical behavior of hydrocarbons, the neglected topic of burning[23] is reviewed and conditions essential for explosive reactions are considered. Inclusion of this material is appropriate because all hydrocarbons react with oxygen and must be considered in relation to fire hazards. Moreover, the very explosions against which safeguards must be considered by nurses are those involving gaseous hydrocarbons. This review also provides an opportunity for the teacher to discover how well the class understands the principle of energy transformation; and with this information, she can form an opinion as to what further review is indicated in the study of metabolism. The study of metabolism also makes a natural setting for consideration of the physiological function of oxygen. In this way, proceeding from unit to unit, it is frequently possible to recall, review, or supplement instruction in the material of general chemistry. Thus, opportunities are provided for the student to enlarge her earlier concepts and integrate her previously acquired knowledge with the study of nursing.

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[22] See Part II, Unit I, pp. 123–128.

METHODS OF INSTRUCTION

It is recommended that the emphasis be placed, whenever possible, on general principles and significant relationships, and that the students be encouraged to use these principles and generalizations in interpreting specific but typical situations such as they will encounter in nursing. Psychologically this approach is considered to be more effective for transfer of learning to new situations than that of focusing attention upon details.[24] When details are needed for some specific purpose, the student should be taught to refer to suitable references. With this approach in mind, questions for study and discussion are suggested in connection with each unit. These are intended merely to serve as a nucleus for further development as teacher and students, together, study situations in which a knowledge of chemistry can be put to practical use.

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[23] See Chap. III, p. 80.

No attempt has been made to elaborate in detail the plan for laboratory study; a few general suggestions are made. It is the belief of the author that in a short course of this type the best results are obtained through the use of rather simple experiments which have been selected either because they illustrate an important principle or find pertinent application in a nursing situation. Technically complicated, time-consuming laboratory experiments are justified only if their value to the nurse is proportional to the time required for their execution.

The relative distribution of time between lecture and laboratory should be studied with reference to the character of the course. The outline presented is not planned for the conventional ratio of one hour of lecture to two hours of laboratory, so generally sanctioned by the college. For a limited study of from 60 to 90 hours, this is an uneconomical plan which too frequently results in superficial and inadequate class presentation and discussion, coupled with a padded laboratory period. Flexibility within the scheduled time, whereby the apportionment of time can be adjusted to the nature of the material being studied, is advocated whenever such a plan can be administered without too great difficulty. When the need for sectioning the class makes a more rigid division of time necessary, it is suggested that the ratio of three hours for presentation and discussion to two hours for laboratory makes practical division for the brief course. Some traditions are better honored in the breach than in the observance. Thoughtful study of the traditional distribution of time for the chemistry course suggests that, in this situation, the tradition should be disregarded.

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[24] "Actually, if facts are organized into meaningful relations and generalized into a principle, the details themselves are likely to be better remembered than if they were acquired in discrete fashion. . . . To cut through specific details to underlying relationships is ordinarily necessary if one would utilize his experience effectively in new situations." Arthur I. Gates, Arthur T. Jersild, T. R. McConnell, and Robert C. Challman, *Educational Psychology*, New York, The Macmillan Company, 1942, pp. 410 f., 518.

WHEN THE FOUNDATION IS NOT A COLLEGE COURSE IN CHEMISTRY

The outline which has been formulated in this study should also offer suggestions to a school of nursing which chooses to develop the entire study within its own curriculum. The needs of its students with relation to the study of organic compounds and of physiological chemistry are the same, but, because the study of general chemistry would now be included within the same course, some reorganization of content would be desirable. The time factor must be reconsidered; some curtailment would probably be deemed necessary. In this connection, the optional units might be omitted, and the advisability of transfer of some content in physiological chemistry to the course in anatomy and physiology might be considered.

The foundation in general chemistry should be evaluated just as carefully as when the college course is used. It should be substantial enough to provide for the development of the study of organic and physiological chemistry; the specific contributions it makes in its own right should also receive consideration. The foundation in general chemistry — whether provided by a standard course in college chemistry or developed within the curriculum of the school of nursing — is exceedingly important.

Chapter V

THE NEXT STEP — TO BUILD CHEMISTRY INTO THE NURSING EXPERIENCE

> *The dignity of an occupation depends on the body of sound theory back of it, as well as on the worth of the service which it contributes to human life, and one might safely say that the ultimate value of that service is directly proportionate to the intelligence with which the theory is applied.*
>
> —Isabel M. Stewart[1]

The value of the program in chemistry must be judged, in the long run, by its effect on nursing practice. Unless it can be built into nursing experience in such a way that a more intelligent and finer quality of nursing service results, the chemistry included in the nursing curriculum will not have fulfilled its purpose. The formal course, however good in itself, can only perform a limited service. Its function is to pave the way for continued study not of chemistry for its own sake but of nursing and the scientific principles which direct the professional practice of nursing. The knowledge which has accumulated in the formal study of chemistry must be continually drawn upon in actual practice. It must penetrate into other courses of which it is an integral part; it must be carried into the hospital ward and be used by the nurse in the community. The responsibility for this continued development rests in a large degree upon those who guide the students in the experiences and studies that are directly associated with the care of the patient.

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[1] Isabel M. Stewart, "Apprenticeship as a Method of Vocational Education," *Seventeenth Annual Proceedings of the National League of Nursing Education*, 1911. p. 192.

BUILDING CHEMISTRY INTO NURSING EXPERIENCE

A responsibility of the nursing faculty. If the student finds in the study of nursing a challenge to apply her knowledge of chemistry to the work at hand, this science will have a continuing interest. When she discovers that she is expected to be able to identify the principles applied in the nursing techniques, to know specifically the purpose of treatments which she administers, and to exercise intelligent control over the environment for the safety and comfort of patients, she will know for a certainty that knowledge of basic sciences is of practical value. She will discover that, in order to interpret simply and intelligently the limitations to which the sick must adjust during illness and in order to give adequate instruction and reliable information in matters relating to health, she must be clear in her own mind as to the scientific principles involved. So used, the knowledge of chemistry will acquire added meaning; and this knowledge will grow in response to new demands imposed by new levels of experience or in response to new developments in chemistry which affect nursing practice. This is as it should be; this is as it must be if nursing is to be ranked among the professions and if it is to attract and hold the interest of alert, intelligent, discerning candidates.

If, on the other hand, the sciences are neglected in the actual study of nursing and in the practice on the ward, the story will be different. When the student discovers that once the classes in chemistry are over there is little demand that she consciously apply the acquired knowledge, this knowledge will dwindle — it will atrophy through disuse. The study loses value in the eyes of the student when she finds that it is rated as unimportant by the nurse who directs the ward experience and is seldom referred to by the instructor in clinical nursing. The supervisor, head nurse, or instructor who is content to plead her own ignorance of science as an excuse for perpetuating a superficial type of instruction that does not require the student to delve beneath the surface and to discover underlying principles is shirking a responsibility. Only the exceptional student, thus unaided, can be expected to perceive the significant relationships and to habitually relate scientific principles to nursing practice.

Breaking the barriers between concurrent courses. A systematically organized chemistry course makes it possible to concentrate a great deal of related content for instruction within a limited time. And a good organization is helpful in identifying parts as needed for subsequent study. But one of the drawbacks often encountered in this type of study is the tendency for the student to pigeonhole knowledge and not draw it out for use in the experiences it was designed to serve. This is one reason why, from the beginning of the chemistry course, the students should be encouraged to form the habit of making pertinent applications to experiences such as those associated with nursing. But this alone does not insure the continued use of chemistry; the habit of application needs to be fostered in other settings as well.

As the curriculum is usually planned in the school of nursing, the studies of chemistry, anatomy and physiology, microbiology, and the introduction to the principles and art of nursing all come during the early period. The three sciences are inextricably interrelated, and all contribute to the study of nursing.[2] It is reasonable, therefore, that this part of the curriculum should be thought of and planned as a composite unit.[3] The division into courses serves to define the emphasis and function of the various studies, but this is no reason why barriers should be set up which discourage the flow of ideas from course to course. If the teachers as a group study the various interdependencies between the courses and work out serviceable sequences and correlations, they will themselves be more aware of relationships to be called to the students' attention. They should be able to evolve a pattern which will be more favorable to integration of these studies in the minds of the students than when each course is conducted as a discrete unit.

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[2] See discussion in Chap. II, pp. 23–29.

[3] "And generally let this be the rule, that all partitions of knowledge be accepted rather for lines and veins than for sections and separations; and that the continuance and entireness of knowledge be preserved. For the contrary hereof hath made particular sciences to become barren, shallow and erroneous, while they have not been nourished and maintained from the common fountain." Francis Bacon, *Advancement of Learning, Book II*, Edited by William Aldis Wright, Oxford, The Clarendon Press, 1885, p. 129.

Extension of chemistry into the applied sciences. Upon the completion of the courses in chemistry and the biological sciences, the study of the student in nursing continues in the applied fields of nutrition, pharmacology, and the introduction to medical science,[4] as well as continuing in nursing. The emphasis has shifted; chemistry is now but one of the many factors contributing to each of these fields. During this period, the study of science extends into the field of pathology and to the consideration of community health problems. The studies of the previous period now furnish the background against which the deviations from normal which are characteristic of various diseases can be projected. If the student does not find that she must continually draw upon her knowledge of all three of the basic sciences in the course of these studies, something is radically wrong with the teaching program.

There is also an important implication herein as to faculty preparation. The teachers chosen to direct these applied sciences should have adequate preparation in chemistry and in the biological sciences, as well as knowledge of the special field. Effective application calls for breadth of knowledge and a high degree of insight — in fact, a greater degree of general competence than is ordinarily required for the less complex undertaking of teaching a single subject.

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[4] In some curriculums this course is entitled "Pathology."

Chemistry in the clinical nursing experience. When the student assumes, under supervision, the actual responsibility for the care of patients, she enters upon the most critical period of her educational experience. The extent to which the knowledge derived from the classroom experiences will actually be brought into use in nursing practice depends to a considerable degree upon the kind of teaching which accompanies the clinical service. A knowledge of the principles and facts of chemistry will throw much light upon various aspects of this experience if the student is encouraged to use it. It can help her to see the reason for many of the procedures which must be followed, to handle supplies and equipment more intelligently, to acquire an understanding of clinical data which tell the story of the patient's progress, and to study with less difficulty and greater comprehension the disease which is disturbing the health of the patient.

The great opportunity for integration. No nurse needs to be told that the ward experience is the most effective integrating activity in the nursing curriculum. It follows that the teaching which is done when the student is directly concerned with the care of the patient is exceedingly important. If she is to become a competent professional worker, one who can safely be trusted to work with independence and initiative, it is here that she must learn how to study the different nursing situations and determine the underlying principles. Only thus will she learn how to adapt her practice to the varied conditions which she will encounter. But it is too much to expect that the inexperienced student will recognize all that is involved in such complex situations as those with which she must deal in caring for the sick; or that she will, automatically, use to the best advantage all of the knowledge at her command. This is where the help of the head nurse or, supervisor is needed. But if clinical instructors are to give the needed guidance to students, they must first of all acquire for themselves a good understanding of the science of nursing.

To be good teachers, they must have the necessary foundation in biological and physical science, and they must have learned to use it consciously and naturally in the teaching — both formal and informal — involved in their work. The great majority of supervisors and head nurses are, at present, poorly prepared for this part of the educational program.

Inadequate faculty preparation an obstruction to progress. This is one of the penalties which nursing education is now paying for the inadequate attention which has been given to science in the past. This deficiency is particularly conspicuous in relation to chemistry; but, because of inherent interrelations, this means that it is present throughout the other sciences as well. As long as this condition persists, it will be exceedingly difficult to develop the type of nursing practice which is needed if nursing is to keep abreast of the developments in medical science. Some schools of nursing are aware of the problem and are making constructive efforts to improve the situation, but, unfortunately, many schools appear to be quite oblivious to its existence, or are even openly antagonistic to the idea that changing conditions are demanding a stronger program in science. The level of education for the school as a whole cannot be raised above the level of the teaching staff — their knowledge, understanding, and development. Whereas added clinical experience can be acquired on the job, lack of foundation in science cannot be supplemented in this manner. The time has come when study in biological and physical science, beyond that which is provided in the basic curriculum, should be recognized as an essential qualification for nurses who hold teaching positions on the clinical services.

Co-operation between clinical teachers and science instructors. To build up a well-prepared faculty, capable of teaching the science as well as the art of nursing, should be a goal for the school of nursing. This will not be achieved in a day. Meanwhile, the school need not wait for ideal conditions before attacking the problem of bringing the sciences into better functional relation with the clinical program. The very practical possibility exists of planning the curriculum in such a way that the various science instructors can contribute more actively to strengthening this part of the educational program. Some of their time might be made available for co-operation with supervisors and head nurses in developing areas in clinical instruction where knowledge of science can make a special contribution. They might also be used as consultants to whom students could be referred when making studies of nursing care which require significant applications of the basic sciences. In thus working together, responsibility for clinical instruction remains with the nurses who hold the dual positions of instructors in nursing and supervisors of clinical services. But the responsibility for helping the student to integrate her knowledge of basic science with the nursing experience should be consciously shared by both science instructors and the teachers in the ward situation.

In such a co-operative experience, all participants might well become learners. The supervisor or head nurse should find that, as she studies the applications of science in situations with which she is already familiar, certain areas in her field of specialization take on new meaning because she sees them in a new relationship. Increased insight should contribute to better work both as a nurse and as a teacher of nurses. The science instructor's thinking would be challenged by the necessity for bringing knowledge of her specialty to bear upon concrete and varied nursing situations; her experience would be enriched by contact with the clinical field. Teachers and students alike should become more aware of the essential continuity and wholeness which exist within a good curriculum.

The school of nursing with a collegiate program. The school of nursing with a combined general and professional program may actually face a more difficult problem in achieving integration of chemistry with nursing experience than does the hospital school. This is likely to be the case if the school is depending upon the standard college chemistry courses, or if the teaching is in the hands of specialists who lack insight into the nursing curriculum as a whole. Having entrusted the science program to the college, the school of nursing does not always recognize the increased importance of selecting personnel for the nursing faculty who have, in addition to the desired clinical experience, the preparation which is necessary for helping the student to relate the science studied in the college to nursing experience.

In this situation, also, it should sometimes be possible to enlist the interest and co-operation of the teachers of the sciences in developing the science content of the program of clinical instruction. This possibility should not be overlooked. Nevertheless, when the teacher of science is not a nurse, the problem becomes more difficult because of his lack of familiarity with the intricacies of the clinical situation. In the course of time, as a result of continued active interest in the study, the subject-matter specialist may, despite the initial handicap, develop real insight into the relation which his field of science has to the nursing curriculum as a whole. This presupposes, however, that the same science instructor will be retained from year to year and will be recognized as belonging on the instructional staff of the school of nursing.

An area in the curriculum which needs further exploration. It is sometimes suggested that studies should be made to determine what science the nurse actually uses in practice, and then the foundation in science developed to conform with this use. Since, in actual practice, nurses have not begun to make as much use of science as they should, this would be a decidedly halfway measure and most inadequate. Some of the more obvious applications of chemistry and the other basic sciences are quite well recognized, but there is a great deal of virgin territory — especially in the clinical areas — still to be explored. Nor will nursing practice reach a really professional level until nurses themselves tackle the job of unearthing and putting into practice the body of science which will lift many of their present activities from the level of technical skill to that of understanding practice consciously directed by the application of scientific facts, principles, and methods.

Chemistry as an Aid to Continued Professional Growth

In-service education. A really good course in chemistry within the nursing curriculum can become a means and a stimulus to continued professional study. For any nurse, it will open up areas which she could not otherwise explore with understanding. For the nurse with a real urge to study and an absorbing clinical interest, it should provide sufficient foundation to enable her to dig into the scientific literature relating to this interest and get deeper beneath the surface than she otherwise could. And this type of study brings its own rewards. What was hard at first gradually becomes easier, and shortly the student discovers that she is reading with ease that which was at first a labor. She will begin to find that she can make use of source materials and thus get the story of progress in medical science and the conquest of disease directly from the pens of workers who are leading in the field. To remove even a degree of the frustration, which many nurses admit to feeling when they attempt to read scientific literature, brings a certain sense of satisfaction to the student, but to explore with understanding and to unearth professional treasures becomes an inspiration. Such experience is apt to spread to the classroom and to the hospital ward, where it helps to lift routine to the level of creative art. Such study may become an appetizer as well, and stimulate an interest in further preparation in order to bring to the job a richer background.

An aid in advanced study. The head nurse, the supervisor, and the instructor should all be encouraged to seek advanced professional preparation; this should include further preparation in biological and physical science.

An adequate foundation in the chemistry related to nursing, provided during the basic education, will stand the nurse in good stead when she goes ahead to advanced study. If the time which has elapsed between her college experience and the period of advanced preparation is not too long, the standard course in general chemistry will usually be accepted for credit. The student can then proceed at once to the next step in the college sequence. The applied course developed in the nursing curriculum may not be accepted as part of the science requirement in a degree program. It should, however, have decided value for the individual student. The survey which this course will have provided will give perspective to the continued study and should help her to recognize more quickly where the new material fits into the whole. When the advanced courses are not designed primarily for students in nursing, the earlier study often suggests where to place the emphasis in gleaning materials for professional use. The advanced study should bring in more detail and sharper delineations, as well as extending the field of the student's knowledge. The nurse should return to her work with a richer background. As a supervisor of nursing service, she should find that she is better able to evaluate nursing practice and procedures in terms of their adherence to scientific principles; hence, she is in a better position to suggest improvements. As a teacher, she should be more competent because she has gathered knowledge which is essential for understanding her work. She should be able to explore more thoroughly and fruitfully in the field of her professional interest and, in turn, help students under her direction to enrich their nursing experience. The quality of nursing service should profit thereby.

THE COST OF INADEQUATE PROVISION FOR SCIENCE WITHIN THE NURSING CURRICULUM

There are some, even in the ranks of nursing, who are content with the nurse who can be depended upon to adhere to orders and carry out nursing procedures with a reasonable degree of skill. They contend that, since she works under the direction of the physician, she does not need to have a command of the science which underlies nursing practice. Frequently these very individuals entrust her with responsibilities and encourage her to carry out techniques which may involve the issues of life and death, yet they would deny her the knowledge which should accompany these responsibilities. The intelligent, conscientious nurse is not content to work in the dark; she recognizes the dangers inherent in her ignorance. She realizes that she is often faced with situations where she must use her own judgment and depend upon her own resources. She knows that poor judgment on her part may be costly in terms of the patient's welfare. When modifications in nursing procedure must be made to meet specific situations, when the unexpected and the unusual arise, the nurse who has a good foundation in basic principles upon which to rely can work with greater safety for the patient and a higher degree of assurance for herself. Some of the concern which many nurses have long felt for a good functional foundation in biological and physical science is related to this need and to the discharge of these responsibilities.

IN CONCLUSION

Better provision for chemistry in the nursing curriculum is one step toward the development of a stronger educational program and one which is more adequate for meeting the needs of the modern nurse. There is no magic by which the college course can make the essential contribution any more than any other good course in chemistry. The real secret lies in establishing a good foundation in the fundamentals of chemistry; selecting the content which is of greatest importance for the nurse; teaching the subject in such a way that the student learns to apply this knowledge to the problems of her daily life; and continuing the conscious development of the study throughout the basic curriculum, as a natural and integral part of good nursing practice.

PART II

Outline for a Chemistry Course in the Nursing Curriculum — to Follow an Introductory Course in College Chemistry

INTRODUCTION

A. *Objectives:* See Chapter II, pages 80–81.

B. *Suggested time:* 60 to 90 hours.

A flexible distribution of time between lecture-discussion and laboratory is recommended, otherwise a proportion of 3 hours for lecture-discussion to 2 hours of laboratory is suggested.

C. *Provision for review of previous chemistry:* One unit only, the first, is specifically devoted to review of material studied previously. It will be discovered, however, that as the study proceeds from unit to unit certain important material from the previous course is outlined for recall, review, or actual teaching in settings where it naturally integrates with the new study.

D. *Summary of units*

I.	Reactions of acids, bases, salts, and water — their applications in nursing	6 to 8 hours
II.	Important classes of organic compounds and some of their relations to nursing	16 to 20 hours
III.	Carbohydrates, fats, and related compounds — as substances of biological importance	8 to 10 hours
IV.	Cyclic and heterocyclic compounds — with an introduction to some important drug groups	8 to 12 hours
V.	Proteins — their nature and peculiar importance in the life of the organism	4 to 6 hours
VI.	Vitamins (an optional study)	3 hours
VII.	A study of digestion with special consideration of enzymes	6 to 9 hours
VIII.	Metabolic reactions — the functioning and fate of oxygen, glucose, fats, and proteins within the cells.	10 to 15 hours
IX.	Maintenance of the environment of the living cell — the integrated functioning of blood, lungs, and kidneys	4 to 8 hours
X.	Other important functionings of salts	2 hours
XI.	Radioactive elements — their biological interest (an optional study)	2 hours

Unit I

REACTIONS OF ACIDS, BASES, SALTS, AND WATER — THEIR APPLICATIONS IN NURSING — 6 TO 8 HOURS

Major objective of unit. To develop a better understanding of the chemical behavior of acids, bases, salts, and water; to learn to make use of this information in situations such as nurses encounter in their work.

Overview. An understanding of this unit is important for the student in nursing because situations involving such contacts are frequently encountered in her work as well as in everyday activities of a more general nature. Most of this chemistry will have been covered in the previous course, but in quite different relationships. It is possible, moreover, that the various reactions have been considered as special instances and that attention has not been called to the generalizations.[1] The suggested practice in analyzing typical situations and applying the previously acquired knowledge affords the student an early opportunity to begin to form the habit of using academic knowledge in the vocational setting. Organization of this chemistry under generalizations as to reaction expectations should be favorable to a transfer of the previously acquired information to the new situation. The review of *p*H relationships and measurements is in preparation for its subsequent use in the study of physiological chemistry, physiology, microbiology, and nutrition.

Pretest. This review unit may be approached through use of a pretest for the purpose of helping both students and teacher to diagnose difficulties. The information thus obtained could be used to direct the emphasis throughout this unit. A good pretest over this important area would also, quite probably, identify students whose preparation in chemistry was either exceptionally strong or exceptionally weak.

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[1] See discussion Chap. III, p. 84 f.

OUTLINE OF CONTENT

A. **Acid, base, salt**
  1. Meaning of terms
  2. Ions contributed by each
  3. Theory of ionization
  4. Strong and weak electrolytes
  5. Equilibrium within a weak electrolyte system

B. **Contacts involving metals**
  1. Metals with water
    a. Specific contacts and resulting reactions
    b. Generalization — reaction expectation
    c. Factors affecting speed of reaction
      (1) In general
      (2) Applied in metal-water contacts
    d. Contacts which do not result in appreciable reaction — with reasoning
  2. Metals with acids
    a. Metals above hydrogen[2]
    b. Metals below hydrogen[2]
    For each:
      (1) Specific contacts
      (2) Reaction expectations
      (3) Important exceptions
      (4) Factors affecting speed of reaction
  3. Metals with bases — contacts from which reactions can be expected
  4. Metals with salts
    a. Contacts from which reactions can be expected
    b. Contacts from which no reaction can be expected
    c. Generalization

SUGGESTED DEVELOPMENT

Lecture, demonstration, and discussion

Review the content suggested in A for the purpose of establishing a common basis of understanding of both the accepted concepts of the theory of ionization and the terms as they may be encountered in reading and as they will be used in this course.

For each type of contact suggested under B, C, and D, select illustrations, preferably of common occurrence: metals encountered in utensils and equipment; solutions used in household and in nursing practice.

Demonstrations of selected contacts pertinent to the applications being discussed will make the study more vivid and interesting.
With the establishment of each generalization, questions involving applications in practical situations can be raised. Encourage students to think not only in terms of the expected reaction but also as to speeds of the reactions and the consequences to be anticipated.

Laboratory

If desired, a laboratory period could be planned to supplement these discussions. However, since this is a review, it is possible that the time will be used to better advantage in

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[2] The expressions "above hydrogen" and "below hydrogen" refer to the position of metal elements in the electromotive series.

OUTLINE OF CONTENT *SUGGESTED DEVELOPMENT*

C. **Contacts of acids, bases, and salts with each other**
   1. Typical reactions
      a. As double decomposition reactions
      b. Conditions which render the extent of such reactions appreciable
      c. Law of mass action
   2. Reaction expectations from contacts of:
      a. Acid with salt
         (1) In general
         (2) With carbonates
      b. Base with salt
      c. Salt with salt
      d. Acid with base

discussion or practical applications and in learning to use the previously acquired knowledge in the new setting.

Selected problems assigned for study might be reported on, either orally or in writing at the next class meeting.

D. **Salts with water**
   1. In hydrolysis
      a. Hydrolysis defined
      b. Accounting for the reaction of the solution
   2. To form hydrates
      a. Commonly encountered hydrates
      b. The reaction involved
         (1) Direct combination
         (2) Exothermic type

E. **Water as an electrolyte**
   1. Ionization of water
   2. The ionization constant
   3. Relative concentrations of hydrogen ions and hydroxyl ions in water solutions
   4. Measurement of the related hydrogen-ion, hydroxyl-ion concentrations
      a. Principle involved
      b. Method demonstrated
   5. The *p*H notation for recording such measurements — its quantitative significance

Lecture and discussion

When the principles underlying the measurement of the related hydrogen-ion, hydroxyl-ion concentrations have been discussed, the student may be introduced to the *p*H notation and its significance. Practice in interpreting these expressions can be afforded in the course of the discussion of typical situations. The students should be encouraged to translate these expressions when they encounter them in reading.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
6. Suggestions as to typical situations in which such measurements are used	**Laboratory** Measurement of hydrogen-ion concentrations, to be recorded in *p*H notation. The colorimetric method is suggested. This is an opportunity also to acquaint the students with Nitrazine or other indicator paper used in the hospital. Solutions such as boric acid, dilute sodium bicarbonate, fruit juices, etc., are suggested for measurement.

SUGGESTIONS FOR STUDY AND DISCUSSION

Note: The teacher should be alert to the many and varied situations which occur in the hospital and household, providing problems which are interesting and pertinent for class discussion or for study assignments. *The following should be regarded as suggestions only.*

1. What reactions, if any, can be expected from contacts of water with aluminum in cooking utensils? What factor limits the extent of this reaction? What is your judgment as to the relative durability of aluminum (a) in a teakettle, (b) in a pressure cooker? Give reasoning.

2. Monel metal is an alloy of nickel, copper, and iron. What reactions, if any, would you expect from contact of each of the following with a Monel surface: (a) boiling water, (b) a solution of washing soda, (c) vinegar, (d) silver nitrate solution.

3. A nickel-plated instrument was left standing in a solution of mercuric chloride. When discovered, there had been an attack on the metal and a greenish tinge was evident in the solution. (a) What reaction had occurred? (b) Should such a reaction be expected? Reason. (c) Would a reaction occur if the instrument were chromium plated? Reason. (d) Would a similar reaction occur from contact of the nickel-plated instrument with sodium chloride solution? With silver nitrate solution?

4. What reaction possibilities can be anticipated from cooking tomatoes in an aluminum dish? (Consider that the following ions are present in tomato juice: hydrogen ions, potassium ions, ferrous ions, chloride ions, citrate ions.) (a) Assemble equations for each of the reactions which you consider possible. (b) Some people are of the opinion that aluminum salts enter the food through such contacts and that these salts are harmful. Are such opinions well founded? Give reasoning

to support your answer. What further information is needed before you can answer the last question. (Consult Benjamin Harrow, *Textbook of Biochemistry*, 4th ed., Philadelphia, W. B. Saunders Company, 1946, p. 436.)

5. In making sour-milk biscuits, the leavening is accomplished through a reaction of sodium bicarbonate with lactic acid in the sour milk. (a) What reaction expectation is typified by this contact? (b) Assemble the equation for the reaction which occurs. (c) How does the heat of the oven affect the course of this reaction? (d) What product is left behind in the biscuit?

6. Silver nitrate is a poison because it reacts with proteins and forms an insoluble product. Sodium chloride is an antidote for silver nitrate poisoning. In answering the following questions, regard protein as hydrogen proteinate. (a) What reaction can be expected when silver nitrate comes in contact with protein? (b) What reaction occurs when sodium chloride comes in contact with silver nitrate? (c) Make use of this information in accounting for the fact that sodium chloride functions as an antidote for silver nitrate poisoning.

7. What reaction is involved in the "setting" of a plaster of Paris cast? Account for the facts (a) that a circular cast may give pressure upon body parts; (b) that when such casts are applied, the patient, although swathed in moist bandages, seldom complains of feeling chilly.

8. The following substances can all be used to neutralize acids: aluminum hydroxide, magnesium oxide, and sodium bicarbonate. What reaction, if any, would be necessary to obtain a solution containing the desired hydroxyl ions? Represent the neutralization reaction common to all. Contrast the speed of reaction to be expected from the use of magnesium oxide and sodium bicarbonate under similar conditions. Account for this difference.

9. The pigment of the red cabbage responds to changes in hydrogen-ion concentration very much as does litmus. A menu listed red cabbage, but when the serving was received, the cooked cabbage was actually blue rather than red. What plausible explanation can you offer as a possible reason for this color?

10. a. Natural tomato juice has an acidity of about *p*H 4. Express the relationship between hydrogen-ion and hydroxyl-ion concentrations in terms of moles per liter. Which is the greater? What is the "reaction" in general of this solution?
    b. If the reaction of tomato juice is adjusted to a *p*H of 9, destruction of vitamin C becomes quite rapid. Interpret the expression *p*H 9 in terms of the related hydrogen-ion hydroxyl-ion concentration of this solution. Comment, from this point of view, on the practice

of adding sodium bicarbonate to tomatoes during the cooking process. (See Henry C. Sherman, *Chemistry of Food and Nutrition*, 7th ed., New York, The Macmillan Company, 1946, p. 342.)

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NOTE: In this unit and those which follow, (T) placed before a reference indicates that it is recommended for the use of the teacher rather than for student use.

Unit II

IMPORTANT CLASSES OF ORGANIC COMPOUNDS AND SOME OF THEIR RELATIONS TO NURSING — 16 TO 20 HOURS

Major objective of the unit. To become familiar with and develop an understanding of certain classes of organic compounds and their typical behavior, from the standpoint of their importance in nursing, either because of direct contributions to safer and more intelligent nursing practice or as a basis for understanding important physiological reactions.

Overview. Although organic compounds exhibit characteristics and behavior peculiar to carbon compounds, the fundamental principles of general chemistry apply in the study of this group. This is important for the student to recognize. Fortunately, many of the organic compounds lend themselves to significant classification, and can be so represented by means of structural formulas. Compounds that belong to the same class can be expected to exhibit similarity in structure and in chemical behavior. In the brief course, it is especially important to take advantage of this fact; it is important that the student acquire an understanding of group relationships and significant group behavior. For the student in nursing, this will prove to be a more serviceable basis for continued study than emphasis on specific processes used in the laboratory or in industry. When structural formulas are used as diagrammatic representations whereby these relationships can be pointed out, they become valuable aids in this study. *Memorization of structural formulas is not advocated.*

This unit is concerned primarily with the study of aliphatic compounds; cyclic compounds will be considered in Unit IV. The classes selected for study include those most frequently encountered in the reactions within living cells. Methods of synthesis and study of organic processes are subordinated to consideration of topics of greater importance for the nurse. The systematic study of nomenclature is suggested because of the help which this will give in courses in pharmacology, in physiological chemistry, and in professional reading. Attention is given to the physiological action of various types of compounds, as well as to that of individual substances, because of the bearing which this has on the use of drugs and on health hazards encountered in hospital, home, and industry.

A review topic relating to energy transformations as they occur during burning and in explosive reactions is included in the study of hydrocarbons. Certain hazards encountered in nursing warrant this review to insure understanding of the principles involved, as well as their intelligent application, in safeguarding against preventable accidents. Incidentally, this is an opportunity to allay some of the unreasonable fears which students sometimes harbor concerning such hazards.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
A. **Introduction to organic compounds**	A. **Lecture and discussion**
1. Basis for classification	Illustrate by use of blackboard and models of molecule structures.
2. Comparison with inorganic compounds a. Number b. Element composition c. Speed of reactions	The history of the differentiation of organic and inorganic compounds affords an interesting approach
3. Theory of molecule structure a. Valence of carbon atom b. Carbon atoms combine:	Encourage students to use their present knowledge of chemistry in reasoning as to behavior of organic compounds.
(1) To form open chains (2) To form closed chains (3) By means of: (a) Single bonds	The preliminary survey, proceeding from hydrocarbons to halogen derivatives, alcohols, aldehydes and ke-

        - (b) Double bonds
        - (c) Triple bonds
4. Formula representations
    - a. The structural formula
        - (1) What it represents
        - (2) Important atom groups
    - b. The semistructural formula — its functioning
5. Classifications of organic compounds
    - a. Aliphatic, cyclic, heterocyclic
    - b. Saturated and unsaturated
    - c. A survey of important classes stressing:
        - (1) Classes similar to inorganic compounds
        - (2) Classes peculiar to organic compounds
        - (3) Typical functioning groups — represented in formulas
        - (4) Systematic relationships from class to class

tones, acids, organic salts, and esters — functions to show typical group structures and class relationships. It will prepare the student to recognize types of compounds referred to incidentally, before the specific group has been studied. Study of nomenclature also begins.

Laboratory

The structural formula now becomes an important tool; hence, opportunity should be provided for practice under supervision in order that students may acquire skill in its use. Recognition of important functioning groups should be encouraged. Similar suggestions apply to work with semistructural formulas.

B. **Hydrocarbons**

1. Typical hydrocarbons with formulas
    - a. Saturated hydrocarbons
        - (1) Alkanes
        - (2) Cycloalkanes
    - b. Unsaturated hydrocarbons
2. Nomenclature
3. Isomeric compounds
4. Occurrence in nature
5. Hydrocarbon mixtures frequently encountered
6. Physical properties
    - a. Physical state
    - b. Solubilities

B and C. **Lecture-demonstration with discussion**

Throughout the entire study, emphasize the behavior common to the group or class of compound.

As the study proceeds from class to class, the students should become familiar with the system of naming. When the general system appears to be understood, a table may be used as a source of information for less frequently used radicals encountered in reading.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
7. Laboratory preparation[1] 8. Chemical behavior	
a. Reaction with oxygen* (1) Reaction expectation (2) An energy product (3) Burning reactions (4) Explosive reactions	* Interruption of the hydrocarbon study at this point is suggested for development of this important review topic.
Review: *Energy transformations — during chemical reactions** 1. Endothermic and exothermic reactions 2. Law of conservation of energy	
3. Burning reactions a. Burning defined b. Conditions essential for burning c. Factors affecting kindling temperature d. Burning with oxygen (1) Oxygen as a source of chemical energy (2) Substances which can be expected to burn with oxygen (3) Conditions essential for burning — in relation to fire control	There will be no trouble in drawing pertinent illustrations for this topic from the hospital situation. The emphasis should be on intelligent use of knowledge of principles for fire prevention and fire control. Avoid using fear as a means for impressing students with a sense of responsibility.
4. Explosive reactions a. Conditions essential for explosive reactions (1) In general (2) As encountered in the laboratory, hospital, or household b. Preventive measures	Demonstration of an explosion, under controlled conditions (a hydrogen-oxygen mixture for instance), helps to impress the fact that explosions can be brought about voluntarily, hence are under human control.

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[1] Methods of laboratory preparation are relatively less important for the nurse than for the chemist. It is suggested that they be limited to methods representative of group behavior, or specifically used in the course.

* Throughout these units, one, two, or more stars are occasionally used. A single star in the left-hand column indicates that it keys with a single star in the right-hand column, and so on for double stars, etc.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
B. **Hydrocarbon (continued)** 8. b. Reactions with halogens (1) Unsaturated hydrocarbons (2) Saturated hydrocarbons (3) Naming the products (a) Common names (b) Chemical names (c) Important radicals 9. Physiological action — in relation to uses and precautions	
10. Some important hydrocarbons — especially occurrence and uses a. Methane b. Ethylene c. Acetylene d. Cyclopropane 11. Rubber and rubber substitutes — chemical nature discussed in relation to hospital uses.	In general, when discussing specific substances or specific situations of interest to the nurse, focus attention upon generalizations which may apply rather than on descriptive details for which the student can be referred to text or reference.
C. **Halogen derivatives** 1. Typical examples: composition, properties, uses a. Ethyl chloride b. Chloroform c. Iodoform d. Carbontetrachloride 2. Physiological activity in general	**Laboratory** Solubilities of hydrocarbons and halogen derivatives; reaction with oxygen; comparative study of methane and ethylene — as saturated and unsaturated hydrocarbons in reaction with bromine.
D. **Alcohols** 1. What is an alcohol 2. Examples — with formulas showing characteristic atom group a. Primary alcohols b. Secondary alcohols 3. Naming customs	**D. Lecture and discussion**

OUTLINE OF CONTENT

4. Preparation from halogen derivatives of hydrocarbons
5. Physical properties — in relation to uses
6. Chemical behavior
    a. Reaction with acids
    b. Oxidation of:*
        (1) Primary alcohols
        (2) Secondary alcohols
    c. To make ethers
7. Some important alcohols
    a. Methyl alcohol
    b. Ethyl alcohol
    c. Isopropyl alcohol
    d. Glycerol
    e. Glycols**
    For each:
        (1) Names and formulas
        (2) Commercial preparation
        (3) Important properties
        (4) Physiological effects
        (5) Uses — in relation to properties

E. **Aldehydes and ketones**
1. Examples with formulas — showing characteristic atom groups
2. Naming customs
3. Preparation from alcohols by oxidation
4. Chemical behavior
    a. Subject to reduction
    b. Subject to oxidation
        (1) Oxidation of aldehydes
            (a) The reaction involved
            (b) Reduction of cupric hydroxide*
        (2) Oxidation of ketones
    c. Reaction of aldehydes with amines

SUGGESTED DEVELOPMENT

* The oxidation study is especially important because similar reactions are often encountered among the metabolic reactions.

** Studies of the use of glycols as disinfectants for control of air-borne infections are appearing in current scientific magazines.

Laboratory

Preparation of ethyl alcohol by fermentation; if time is adequate — distillation with recognition of ethyl alcohol by iodoform test; inflammability of common alcohols, also ether; oxidation of methyl and ethyl alcohol; preparation of an ester.

Ethyl alcohol as a solvent — it may be well to include a demonstration of its effect on a varnished surface.

E. **Lecture-demonstration and discussion**

Both the naming customs and the study of the reduction-oxidation sequence provide opportunities for calling attention to the relationship of these compounds to alcohols, on one hand, and to acids, on the other.

* The reduction of cupric hydroxide is of special interest since it is the basis for Fehling's and Benedict's tests for glucose. Demonstration, with class discussion, is suggested.

OUTLINE OF CONTENT

- d. Polymerization of aldehydes
  - (1) Nature of reaction
  - (2) Paraform and paraldehyde

5. Aldehydes of special interest
   - a. Formaldehyde
     - (1) Occurrence in Formalin
     - (2) Physical properties
     - (3) Chemical behavior
       - (a) As a reducing agent
       - (b) Reaction with ammonia
       - (c) Reaction with proteins
     - (4) Uses
       - (a) As a disinfectant
         - in general
         - from hexamethylenamine
       - (b) As tissue preservative
       - (c) Industrial uses
   - b. Chloral and chloral hydrate*
     - (1) Composition
     - (2) Physiological effect
   - c. Aldehyde sugars
6. Ketones of special interest
   - a. Acetone
     - (1) Preparation
     - (2) Commercial use as a solvent
     - (3) Physiological occurrence
   - b. Of physiological importance
     - (1) Pyruvic aldehyde
     - (2) Pyruvic acid
     - (3) Diacetic acid
   - c. Fructose — a ketone sugar

SUGGESTED DEVELOPMENT

* Note similarity in chemical structure and physiological effect between chloroform and chloral, also between chloral and tribromethanol.

Laboratory

Oxidation of formaldehyde and glucose with cupric hydroxide and ammoniacal silver nitrate; action of formaldehyde with proteins; study of hexamethylenamine preparation; also effect of heating in acid, basic, and neutral solution.

Acetone; physical properties; as a solvent; reaction with oxygen; test for its recognition.

OUTLINE OF CONTENT

F. **Organic acids, salts, and esters**
  1. Organic acids
    a. Examples with formulas showing:
      (1) The carboxyl group
      (2) The ionizable hydrogen
    b. Naming customs
    c. Preparation
      (1) Oxidation of an aldehyde*
      (2) Hydrolysis of salt or ester*
    d. Chemical behavior
      (1) As electrolytes*
      (2) Reaction with metals*
      (3) Reaction with bases*
      (4) Reaction with alcohols*
      (5) Acetylation
    e. The fatty acids
      (1) As a homologous series
      (2) As products of fat hydrolysis
    f. Dicarboxylic acids — examples
    g. Hydroxy acids
      (1) Examples — with formulas
      (2) Naming
      (3) How produced
      (4) Lactone formation
      (5) Commonly encountered hydroxy acids
        (a) Of plant origin
        (b) Of physiological importance
  2. Organic acids and esters
    a. Typical examples with formulas
    b. Contrasted as to:
      (1) Composition
      (2) As electrolytes

SUGGESTED DEVELOPMENT

F. and G. **Lecture and discussion**

Charts can be used to advantage to illustrate the different types of acids and their formula representations, also to show relationship of salts and esters to acids and to each other.

* The topics thus indicated call for a review of reaction expectations studied previously. Both student and teacher are, in this way, afforded an opportunity for appraisal of progress and for further review if needed.

The study of salts and esters likewise includes review material, notably for recall of the law of mass action.

Laboratory

Reaction of an acid with an alcohol; hydrolysis of a salt — a soap might be used; hydrolysis of an ester — if desired, hydrolysis of fats; reaction of soaps with acids — because of practical importance; oxidation of oxalic acid by potassium permanganate, both as an oxidation-reduction reaction and as a method for removal of potassium permanganate stains.

OUTLINE OF CONTENT

- c. Preparation from acids
  - (1) Of organic salts
  - (2) Of esters
    - (a) A reversible reaction (law of mass action)
    - (b) Functioning catalysts
- d. Hydrolysis
  - (1) Of organic salts
  - (2) Of esters
- e. Occurrence in nature
  - (1) Organic salts in fruits — nutritional importance
  - (2) Esters
    - (a) In general
    - (b) Fats and waxes

G. **Amines and amino acids**

- 1. As derivatives of ammonia
  - a. Primary amines — amino group
  - b. Secondary amines — imino group
  - c. Tertiary amines
- 2. As nitrogen bases — reaction with acids to make soluble salts
- 3. Amino acids
  - a. Examples with formulas
    - (1) The carboxyl group
    - (2) The amino group
  - b. Reaction of an amino acid
    - (1) As an acid
    - (2) As a nitrogen base
  - c. Products of protein hydrolysis
- 4. Other amines and related compounds of biological interest

SUGGESTED DEVELOPMENT

The study of amines and amino acids provides an introduction to the subsequent study of medicinal compounds, notably the alkaloids and aniline derivatives; also to the study of proteins.

SUGGESTIONS FOR STUDY AND DISCUSSION

Introduction to organic compounds

1. What was the original differentiation between organic and inorganic compounds? What famous discovery threw doubt on this concept and led, eventually, to adoption of a new basis for classification? What is the present basis for classification?
2. Contrast speed of reaction of inorganic and organic compounds in in general. Suggest one explanation, theoretical, which may account for this difference.
3. Assemble structural formulas for compounds having the following empirical compositions: CH_4, C_2H_6, C_2H_4, CH_3Cl, CH_2O, C_6H_6, C_6H_5Cl
4. Assemble both structural and semistructural formulas for compounds represented by the following formulas: C_3H_8, C_3H_6, C_2H_5OH, $C_2H_4Cl_2$, C_5H_{10}, C_5H_8
   Notice instances where two different structural formulas are possible.
5. Starting with the hydrocarbon propane, which has the formula C_3H_8:
   a. Assemble both structural and semistructural formulas for the following related compounds:
      (1) Propane
      (2) Propyl alcohol
      (3) Propanol
      (4) Propanal
      (5) Propanone
      (6) Propionic acid
      (7) Sodium propionate
   b. Indicate the classification of each of these compounds and mark off the typical atom group by which the class of compound is recognized.

Hydrocarbons and halogen derivatives

1. For practice in use of structural formulas and naming, the following suggest typical problems of which many variations are possible.
   a. Assemble structural and semistructural formulas for the following hydrocarbons: ethane, propane, *n*-butane, isobutane, *n*-decane, propane, propylene, propyne, cyclopropane, cyclobutane, butadiene, 2-methyl butadiene.
   b. How many isomers of pentane are possible? Assemble structural and semistructural formulas for each and distinguish by name.
   c. Assemble structural formulas for all of the compounds which might result from the reaction of chlorine with methane; from the reaction of bromine with ethylene. Assign a distinguishing name to each of these compounds.

2. How could you remove a spot of mineral oil from a nonwashable fabric? On what properties exhibited by hydrocarbons is your judgment based? Mention other instances in which a similar procedure might be followed.

3. Account for the softening of rubber when it is frequently lubricated with mineral oil or petroleum jelly.

4. Many organic compounds are inflammable. (a) From the standpoint of chemical composition, why should this be expected? (b) With reference to hydrocarbons and hydrocarbon mixtures, which, in general, would you expect to exhibit low kindling temperatures? Reason. (c) What practical significance attaches to these facts?

5. What is the composition of paraffin? Why should you be on guard against fire when melting paraffin for use? Explain on the basis of composition and energy transformation. In the event of a fire of such origin, what method of extinguishing fires is practical? Account for your choice.

6. A typical illuminating-gas mixture contains the following substances: hydrogen, carbon monoxide, methane, and acetylene.
   a. Assemble equations for the reactions which take place when an adequate oxygen supply for complete burning of the components of the illuminating-gas mixture is provided.
   b. Account for the appearance of carbon when the burner is poorly adjusted.
   c. Under which of the above mentioned conditions can the higher temperature be obtained? Reason.
   d. What investigation would you make, or what adjustments would you suggest, if the flame of a gas burner were depositing carbon on a cooking utensil?

7. It is well known that inhalation of illuminating gas has sometimes resulted in death. What physiological action is attributed to each of the above-mentioned components of illuminating gas?

8. What, in general, are the conditions which must be established to produce an explosive reaction? Illustrate by reference to the situation which can easily develop in the oven of a gas stove. What habitual technique for lighting a gas oven will safeguard against the possibility of a disastrous explosion? Explain.

9. In the hospital operating room, whenever either ethylene or cyclopropane anesthesia is in use, careful precautions are observed to guard against possible sources of ignition. What two possible hazards are involved? Explain in such a way as to show your understanding of the reaction possibilities.

10. Various mixtures of volatile hydrocarbons, also carbontetrachloride, are widely used both in the home and in industry as solvents for fats and oils. What precautions are essential, for each type of solvent, to insure the safety of the worker? Reasons.

Alcohols

1. Contrast the reaction of ethyl alcohol and hydrochloric acid with that of sodium hydroxide and hydrochloric acid, as follows:
   a. The general reaction expectation for each contact.
   b. The specific reactions, represented by equations. What significant difference in the nature of the products?
   c. The speeds of the two reactions under similar conditions. Mention one factor which helps to account for this difference.
   d. A method which might be used, in each, to carry the reaction to completion. Why is the same method not applicable to both reactions?
2. Varnished surfaces should be protected from contact with ethyl alcohol. a. Why is this precaution necessary? b. What preparations in common use, other than those specifically designated as alcohols, should be considered in this connection?
3. Methanol is used as a solvent in a variety of industries. Mention two hazards encountered in its use against which workers need protection.
4. Isopropyl alcohol can be substituted for ethyl alcohol for local use as a rubbing lotion and as an antiseptic. Compare the two alcohols in relation to the following:
   a. Chemical composition, as represented by their semistructural formulas.
   b. Classification as alcohols.
   c. Volatility — what is your expectation judged from information to be gathered from their formulas? Is this confirmed by observation of the alcohols themselves? Which of these alcohols should have the more refreshing effect when used as a rubbing lotion. Reasoning.
   d. Physiological effects. (Consult Glen L. Jenkins and Walter H. Hartung, *Chemistry of Organic Medicinal Products*, pp. 69–71.)
5. Avertin is known to chemists as 1, 1, 1-tribromethanol. What physiological action can be expected from such a compound? (Consult: Jenkins and Hartung, *op. cit.*, pp. 69–71, and p. 51.) Summarize your conclusions on the basis of its chemical nature; then consult a textbook in chemistry or pharmacology as to the use of this compound.

Aldehydes and ketones

1. Represent by word and formula equations the series of reactions by which acetic acid is made from ethyl alcohol. What part do bacteria play in this reaction as it occurs in the making of cider vinegar?

2. Follow by means of word and formula equations the series of reactions which take place in the oxidation of isopropyl alcohol to make acetic acid, carbon dioxide, and water. Make a general statement as to the reaction expectation typified.
3. It is claimed that some of the toxic effects of methyl alcohol are due to formation of formaldehyde and formic acid following its absorption by the body. (See Jenkins and Hartung, *op. cit.*, p. 72.) What type of reaction would be involved in producing these products? Represent by equations.
4. Account for the fact that both formaldehyde and glucose will reduce cupric hydroxide. What visual evidence is provided when this reaction has taken place? What test used in urinalysis is an application of this reaction?
5. Account for the irritating effect of formalin on tissue.
6. What two possible attacks on the microorganism might account for the disinfectant action of formaldehyde?
7. To what is the action of hexamethylenamine as a urinary antiseptic attributed? Assemble the equation representing the making of the antiseptic agent. Why is it important to test the urine for reaction to litmus when this medication is being used?
8. Account for the fact that acetone, when used as a solvent for nail polish, often has the effect of making the fingernails dry and brittle.
9. Represent the reaction whereby acetone is made from diacetic acid.

Organic acids, salts, and esters

1. Unlike most organic acids, formic acid is a good reducing agent. Account for this on the basis of its structural formula.
2. Why are organic acids employed in preference to inorganic acids as antidotes for bases in first-aid treatments?
3. It is believed that in both lactic acid production by bacteria, and reactions which take place in muscle cells, pyruvic acid is the precurser of lactic acid. What type of reaction is involved? Represent by equations, using semistructural formulas.
4. Contrast organic salts and esters as to chemical behavior, noting both similarities and differences. Account for the difference in speed of reaction in hydrolysis of organic salts and esters. How may the speed of the hydrolysis of an ester be increased?
5. The idea is sometimes encountered that fruit juices, although sour to taste, are really basic in their effect following absorption. What explanation can you offer to clarify this concept. (See Henry C. Sherman, *Chemistry of Food and Nutrition*, 7th ed., New York, The Macmillan Company, 1946, pp. 251–253).

6. What differences in products result from the hydrolysis of fats when the catalyst used is: (a) an acid, (b) a base, (c) a lipase?
7. Starting with the hydrocarbon ethane, trace a series of possible reactions ending with the ester ethyl acetate. Represent by both structural and semistructural equations, and name all of the intermediate organic compounds.

Amines and amino acids

1. Why are amines called nitrogen bases? Illustrate by reference to typical reactions with acids.
2. Assemble structural formulas for each of the following amino acids; then look up the common names for these compounds.
    a. α-aminoacetic acid
    b. α-aminopropionic acid
    c. α-amino-β-hydroxybutyric acid
    d. α-amino-isocaproic acid
    e. α, ϵ-diaminocaproic acid
3. Illustrate the amphoteric nature of amino acids by reference to the reactions of alanine with (a) hydrochloric acid, (b) sodium hydroxide. Name the organic product of each reaction.
4. Look up the formula for the compound α-lecithin, then:
    a. Locate the amine structure in its molecule.
    b. Locate the atom groupings which indicate that this compound is an ester.
    c. What products might you expect to result from the hydrolysis of lecithin?
    d. Represent the hydrolysis reaction, using structural formulas, and naming each product.

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Unit III

CARBOHYDRATES, FATS, AND RELATED COMPOUNDS — AS SUBSTANCES OF BIOLOGICAL IMPORTANCE —

8 TO 10 HOURS

Major objective of the unit. To develop an understanding of the characteristics and chemical behavior of carbohydrates, fats, and related compounds, particularly in relation to their biological importance; in this way, to provide a foundation for the subsequent study of digestion and metabolism.

Overview. Carbohydrates and fats, from the standpoint of their chemical behavior, belong with the aliphatic compounds; therefore, their study naturally follows and is an application of the chemistry developed in the previous unit. For nurses, the primary interest in these compounds lies in their biological importance. At the same time, both carbohydrates and fats have other interests related to nursing. For instance, both the principles and the technique of the common laboratory test for reducing sugars will be presented and used in this study; later it will be used in the study of urinalysis. Soaps and detergents are also included, not only because of their importance as cleaning agents but because of the germicidal value claimed for some of the new compounds.

The topic of fermentation, outlined in this unit, merits expansion in the longer course of 80 to 90 hours. This type of reaction is now recognized as important not only in relation to foods, their preparation and preservation, but also as typical of important reactions in the life activities of both microorganisms and the higher animals — for instance, the intermediate stages of carbohydrate metabolism in muscle cells.

A review topic. At this stage, it becomes important to make sure that the students have an understanding of solutions, colloidal dispersions, and emulsions, since these must be considered in the study of all three of the great food substances as well as in other connections of everyday concern. It may be assumed that a study of solution, and perhaps of colloidal dispersions as well, was included in the general chemistry course. The review is for the purpose of recalling this material and relating it to biological phenomena.

OUTLINE OF CONTENT

A. **Carbohydrates**
  1. Substances classed as carbohydrates, and their occurrence in nature
  2. Synthesis in plant cells
  3. Composition
     a. Constituent elements
     b. Characteristic atom groups
  4. Classification
     a. On basis of hydrolysis
     b. As hexoses, pentoses, etc.
  5. Important monosaccharides
     a. Formula representations
        (1) Empirical formula
        (2) As aldoses and ketoses
        (3) Cyclic formulas
     b. Tautomeric changes
        (1) Equilibrium between cyclic and active forms
        (2) Interconvertability of glucose and fructose
     c. Ascorbic acid — a monosaccharide derivative
  6. Important disaccharides
     a. Formula representations
        (1) Empirical formula
        (2) Structural formulas
     b. Hydrolysis of disaccharides
        (1) The reaction involved
        (2) Favoring conditions
        (3) Functioning catalysts
  7. Important polysaccharides
     a. Formula representations

SUGGESTED DEVELOPMENT

A. **Lecture and discussion**

Blackboard diagrams or simple charts are helpful in illustrating differences in molecule structure, also in making more vivid the process of hydrolysis.

In stressing the characteristic atom groups, the way is prepared for helping the students to see the relationship between the chemistry of these compounds and that of alcohols, aldehydes, and ketones studied previously.

OUTLINE OF CONTENT | *SUGGESTED DEVELOPMENT*

- b. Supposed structure of molecules of:
  - (1) Starches and dextrins
  - (2) Glycogen
  - (3) Celluloses
- c. Hydrolysis of polysaccharides
  - (1) The series of reactions
  - (2) Catalysts
  - (3) Other favoring conditions
- d. The iodine test as a means for recognition*

8. Physical properties
   - a. Comparative sweetness
   - b. Solubilities and diffusion tendencies

* The characteristically different colors obtained with starches, dextrins, and glycogen will later be used in following the progress of salivary digestion.

Review: *Solutions and colloidal dispersions*

1. True solution, colloidal dispersion, and suspension contrasted
2. True solution
   - a. Defined
   - b. Solvent and solute
   - c. Theoretical explanation for conditions in true solutions
   - d. Diffusion of components through membranes**
     - (1) Permeable membranes
     - (2) Semipermeable membranes
     - (3) Theoretical explanation for diffusion
     - (4) Importance of diffusion in relation to interchanges of material between the cell and its environment
       - (a) Absorption, transportation, and elimination
         - of nutrients
         - of poisons

** In general chemistry, the interest in diffusion is often as a method for separation of colloidal material from substances in solution. The different emphasis here indicated is that which will be needed in the study of physiology, of action of disinfectants, and in problems relating to administration of medicines.

OUTLINE OF CONTENT

- (b) Isotonic, hypotonic, and hypertonic solutions
- 3. Colloidal dispersions
  - a. Size of dispersed particles
  - b. Characteristic behavior
    - (1) Light penetration
    - (2) Filtration
    - (3) Diffusion possibilities — biological significance
  - c. Theoretical explanation for these properties
  - d. Gel formation
    - (1) Physiological importance
    - (2) In relation to cookery

A. Carbohydrates (continued)

- 9. Optical activity
  - a. Meaning
  - b. Biological significance
- 10. More concerning chemical behavior
  - a. Reaction with oxygen
    - (1) Matter products
    - (2) Energy products
  - b. With oxidizing agents*
    - (1) In general
    - (2) With cupric hydroxide in Fehling's and in Benedict's reagents
      - (a) The reagents compared
      - (b) The reaction
      - (c) The underlying principle
      - (d) The technique explained
  - c. As aldehydes and ketones — with reducing agents

SUGGESTED DEVELOPMENT

* Because the reduction of cupric hydroxide is the reaction usually used as the test for a reducing sugar both in urinalysis and for blood sugar, it is of special interest. Because the nurse will use this test herself in urinalysis, she should understand the underlying principle as well as the necessity for exact technique to obtain reliable results.

OUTLINE OF CONTENT

- d. Fermentation
    - (1) Alcoholic fermentation
        - (a) Enzymes in yeast
        - (b) Hydrolysis reactions
        - (c) Fermentation of monosaccharides
        - (d) Where encountered
    - (2) Lactic acid fermentation
        - (a) Enzymes of bacterial origin
        - (b) Fermentation reaction
        - (c) Products
        - (d) Practical interest
- e. Monosaccharides dehydrolyzed for storage
    - (1) In plant cells
    - (2) In animal cells
    - (3) Biological importance

11. Celluloses
    - a. Reaction with oxygen
    - b. Hydrolysis
    - c. Cellulose esters and their uses
12. Other varieties of carbohydrate — pectins and gums
13. Importance of carbohydrates as foods

B. **Fats**

1. Occurrence in nature
2. Synthesis in plant and animal cells
3. Natural fats as mixtures
    - a. Typical examples
    - b. Fats and oils
4. Physical properties
    - a. Feeling, tastes, odor

SUGGESTED DEVELOPMENT

Laboratory

The proportion of time for this study can be adjusted to the length of the course. For a short course, typical carbohydrates may be selected for study; for a longer course, a larger group might be included. The following studies are suggested: solubilities and relative sweetness; diffusions through membranes; hydrolysis; fermentation; reduction of cupric hydroxide — using various reagents and various sugars and dilutions; tests for recognition of carbohydrates.

B. **Lecture-demonstration with discussion**

A collection of typical fats, those encountered in the hospital, will call attention to both variety of sources and of uses. A representative collection will include fats of plant origin, liquid and solid animal fats, hydrogenated fats, and fats used for food and for medicinal purposes.

OUTLINE OF CONTENT

- b. Physical state — determining factors
- c. Solubilities and their importance
  - (1) In general
  - (2) Fat-soluble vitamins
- d. Form emulsions with water*
  - (1) Emulsion defined
  - (2) Emulsifying agents and their functioning
  - (3) Practical importance of emulsions
    - (a) In cleaning and cookery
    - (b) Homogenized fats
    - (c) In medicinal preparations
  - (4) Physiological importance of emulsion
    - (a) In digestion of fat
    - (b) In transportation of fat in blood and lymph
    - (c) Emulsifying agents provided by nature

5. Fats as esters
   - a. Important fatty acid radicals
   - b. Saturated and unsaturated fats

6. Chemical behavior
   - a. Reaction with oxygen
   - b. Hydrolysis
     - (1) The reaction involved
     - (2) Conditions favorable to hydrolysis — including catalysts
     - (3) Physiological importance
   - c. With bases to make soaps
     - (1) Reaction involved

SUGGESTED DEVELOPMENT

* For some students, a study of emulsion may have been included in the earlier course. It is improbable, however, that its application in physiology will have been considered.

OUTLINE OF CONTENT — *SUGGESTED DEVELOPMENT*

- (2) Commercial production of soap
- (3) How soaps function in cleaning
- (4) New detergents compared with soaps*
  - (a) Chemical composition
  - (b) Advantages
  - (c) Bactericidal action

d. Hydrogenation of unsaturated fats
  - (1) The catalyzed reaction
  - (2) Commercial importance
  - (3) Nutritional value of hydrogenated fats

e. Oxidation of unsaturated fats — in relation to rancidity

f. The iodine number of fat
  - (1) How determined
  - (2) Its significance

C. **Other lipids**

1. Substances classed as lipids
2. Phospholipids
   - a. Chemical composition
     - (1) In general
     - (2) Lecithins
   - b. Solubilities
   - c. Essential components of cells
3. Sterols
   - a. Chemical nature
   - b. Cholesterol
     - (1) Occurrence
     - (2) Chemical composition
     - (3) Physiological and pathological significance

* Be on the lookout for information in current literature regarding these new detergents and their uses. Note the distinction between anion-active and cation-active detergents in relation to germicidal action.

Laboratory

Study of fat solubilities; emulsions — with various emulsifying agents such as soap, proteins, bile salts, etc.; hydrolysis of fats and making of soap; iodine numbers for fats; acrolein test for glycerol and fat — as distinguished from other oils.

In connection with the soap study, reaction of soap with acids, and with salts; comparison with other detergents; reaction of Zephiran (a cation-active detergent) with soap.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
(4) Chemical relation to bile salts	
c. The vitamin-D group and their precursers*	* If Unit VI is to be used in the course, this topic should be omitted at this point.
(1) Occurrence	
(2) Antirachitic functioning	
(3) Chemical structure of vitamins and precursers — used to show relations	
4. Waxes	
a. Composition	
b. Occurrence in nature	
c. Functioning	

SUGGESTIONS FOR STUDY AND DISCUSSION

Carbohydrates

1. Prepare a chart of the common carbohydrates classifying them (a) according to their natural occurrence in plants and animals; (b) as monosaccharides, disaccharides, and polysaccharides.

2. What is the origin of plant carbohydrate? Assemble the equation for the reaction involved. What is the function of light in this reaction? What becomes of the sunlight during this reaction? List three reasons why this is one of the most important reactions in all nature.

3. What is a tautomeric change? Illustrate by means of structural formulas the change which is believed to take place when glucose is made from fructose. What evidence can be obtained in the laboratory that such a change is possible?

4. Represent by means of structural formulas the equilibrium which is believed to exist in glucose solution between the inactive cyclic forms and the active aldehyde form. What would be the effect on this system of introducing an active oxidizing agent? Explain.

5. Sucrose and lactose have the same chemical composition and, gram for gram, the same caloric value as foods. Account for the use of lactose in beverages when a high caloric intake is desired.

6. What is the common name for the compound ascorbic acid? What is the origin of the name "ascorbic acid?" From what source was this compound originally isolated? From what are commercial supplies

of ascorbic acid now made? Look up and compare the structural formulas for glucose and ascorbic acid.

7. Contrast a solution of glucose with a thin colloidal dispersion of cooked starch with regard to the following: (a) appearance, (b) size of suspended particles, (c) tendency toward separation, (d) filtration, (e) diffusion through permeable membrane. How are these differences accounted for, theoretically?

8. Of what advantage is it to the plant or animal that the carbohydrate in its circulating fluid is a sugar, whereas the carbohydrate for storage is a polysaccharide?

9. a. What products are obtained on the hydrolysis of each of the following: sucrose, lactose, maltose?
   b. How is the hydrolysis of disaccharides favored in cooking? What provision is made within plant cells to favor hydrolysis?
   c. Consult a textbook in chemistry for the structural formula of the sucrose molecule; then assemble an equation representing the hydrolysis reaction. In this instance, what two monosaccharide molecules result?

10. a. What stages are believed to be involved in the hydrolysis of starch, and what intermediate products appear? Represent by word equations.
    b. What do these factual findings suggest concerning the structure of the starch molecule? The dextrin molecules?
    c. What product is obtained on the hydrolysis of glycogen. What is believed to be the character of the glycogen molecule? (See W. Z. Hassid, "The Chemistry of the Carbohydrates," *Annual Review of Biochemistry*, Vol. 13, pp. 61, 71–72 for results of recent studies.)

11. What is commercial glucose? (Consult the *United States Pharmacopoeia.*) What substances other than glucose might be present in this material? Would they render it undesirable for food? What name is used for the chemically pure glucose for intravenous injection?

12. Explain why similar results are obtained with both Fehling's and Benedict's reagents in testing for glucose. What reaction is common to both? What are the advantages in the use of Benedict's modification? Is this test specific for glucose? Support your answer with evidence.

13. Account for the following differences in appearance which are encountered in the use of Benedict's test under controlled conditions. Interpret each in terms of the relative concentration of the reducing sugar.

    a. Clear blue solution after heating.
    b. Cloudy green appearance after heating.

   c. Orange-colored suspension after heating.
   d. Brick-red suspension after heating, with precipitation leaving a practically colorless solution.

14. A specimen of urine from a nursing mother gave a positive test with Benedict's reagent. What two sugars should be considered as possibilities under these conditions? Suggest a further test which could be used to distinguish between these two sugars.

15. What tests could you apply to distinguish solutions of sucrose, lactose, and maltose?

16. Mention several situations in which fermentation of sugars with production of alcohol and carbon dioxide are encountered. What sugars are subject to such fermentation? What is the source of the catalyst in each instance?

17. Follow the sequence of reactions involved in the leavening of bread with the use of yeast. What is the function of the yeast? What temperatures are most favorable for these reactions? Explain.

18. What is the source of lactic acid made during the souring of milk? What part do bacteria play in this process? Mention some varieties of bacteria which are capable of bringing about this series of chemical reactions. Compare the sequence of reactions with those in fermentation by yeast enzymes.

Fats and detergents

1. What is the basis for the belief that fats are made, within plant cells, from carbohydrates? Cite instances from your own experience with plants used as foods which appear to support this belief.

2. What differences in composition account for the differences in physical state of the following:

   a. Butter fat and mutton tallow.
   b. Cottonseed oil and the hydrogenated fat which is made from it.

3. Account for the drying effect of gasoline or carbontetrachloride, used as cleaning agents, when in contact with the hands of the worker. Mention other instances where the skin should be protected against contact with fat solvents.

4. Locate formulas for the fat soluble vitamins — A, D, E, and K. From the standpoint of chemical composition, why should you expect that these substances would be soluble in fat?

5. Mention several instances in cookery in which an emulsion is used as a means for holding fat in dispersion. In each instance specify the emulsifying agent used.

6. What is the function of an emulsifying agent? Account for the detergent action of soap on the basis of its action as an emulsifying agent.

7. Account for each of the following and represent by equations any reactions which take place as a result of the suggested contacts.

   a. The interference of hard water with the action of soap.
   b. The interference of soap with use of the disinfectant mercuric chloride.
   c. The advisability of rinsing the lemon squeezer before washing with soap and water.

8. Zephiran chloride is known as an invert soap or cation-active detergent. Consult *New and Nonofficial Remedies, 1946*, Council on Pharmacy and Chemistry of the American Medical Association, American Medical Association, Chicago, for information regarding this compound, then answer the following:

   a. Assemble the semistructural formula for a representative compound. To what class of compounds studied previously does it belong?
   b. Account for the terms "invert soap" and "cation-active detergent."
   c. Why does ordinary soap interfere with the use of this detergent? What reaction might you expect between sodium stearate and Zephiran chloride? What would be the nature of the resulting compound?
   d. What claims are made for this substance as a bactericidal agent?

9. a. To what class of compounds do soaps belong? Represent the reaction involved in making a typical soap.
   b. What differences in preparation and composition distinguish toilet soaps from laundry soaps? (Consult references in organic chemistry for information.)
   c. Account for the irritating effect which some cleansing soap powders have on the skin.

10. Hydrogenated fats have come to have an important place in the American diet.
    a. What is a hydrogenated fat? What naturally occurring fats are used for hydrogenation?
    b. Represent the reaction involved in hydrogenation, using glyceryl oleate as a typical fat.
    c. Mention some of the preparations in which hydrogenated fat is used for food. Have such fats any use other than for food?
    d. How does a hydrogenated fat compare with natural fat from the standpoint of caloric value?
    e. Compare margarine with butter from the standpoint of nutritional value. Use only reliable scientific information in making this comparison.

11. What is meant by the term "rancid"? How may a fat become rancid? Explain on the basis of your knowledge of chemistry.
12. Why must some fat be included in a well-balanced diet? (Consult recent scientific literature for information relating to essential fatty acids.)

Other lipids

What characteristics are common to lipids? What classes of compounds are found in this group? Prepare a chart of lipids of physiological importance indicating: (a) chemical relationships, (b) their physiological occurrence or importance.

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Unit IV

CYCLIC AND HETEROCYCLIC COMPOUNDS — WITH AN INTRODUCTION TO SOME IMPORTANT DRUG GROUPS — 8 TO 12 HOURS

Major objective of the unit. To become familiar with some of the characteristics of cyclic and heterocyclic compounds as a basis for (1) the study of compounds of physiological importance and their behavior, and (2) the subsequent more comprehensive study of drugs in the course in pharmacology and therapeutics.

Overview. The study of cyclics has been introduced at this point because, whereas carbohydrates and fats belong with the aliphatic compounds, both proteins and vitamins — which follow this unit — contain cyclic or heterocyclic structures.

Cyclic compounds are of interest to the student in nursing *first*, because of their frequent occurrence among substances of physiological importance and *second*, because many important drugs and disinfectants are found in this group. These interests determine the emphasis of this study. The introduction to drug groups is for the purpose of pointing out chemical relationships and the frequency with which common group action is associated with common structural features. The method of study thus suggested should enable the student to recognize other such significant relations among compounds which she will encounter in the course in pharmacology, thus simplifying the study in that course. All of the groups suggested for study contain drugs which are more or less well known, even outside of hospital experience. This study may also stimulate interest in the progress which the pharmaceutical chemist is making in the search for better medicinal compounds — more effective in action and freer from undesired side actions.

OUTLINE OF CONTENT

A. Carbocyclic compounds

1. Contrasted with:
    a. Aliphatic compounds
    b. Cycloalkanes
2. The benzene ring
    a. History
    b. Significance of structure
    c. Conventional representations
3. Occurrence of cyclic compounds
    a. In nature
    b. Important compounds obtained from coal tar
4. Benzene — the parent compound
    a. Physical properties
    b. Chemical behavior — as typical of cyclic compounds*
    c. (1) Oxidation
        (2) Chlorination
        (3) Nitration
        (4) Introduction of side chain
    d. Naming of derivatives
        (1) The phenyl radical
        (2) Numbering substitutent positions
        (3) Ortho-, meta-, and para- positions
    e. Industrial uses
    f. Physiological effect of benzene and related compounds — an industrial hazard
5. Other carbocyclic hydrocarbons — toluene, ethyl benzene, xylenes
    For each:
    a. Formula representations
    b. Names
    c. Chemical reactions
        (1) On the ring

SUGGESTED DEVELOPMENT

Lecture and discussion

The blackboard should be used freely to illustrate the discussion of formulas. Simple charts may be prepared to show formulas with associated names for compounds with which students should become familiar. Blackboard space is usually at a premium and these more permanent diagrams can be referred to over and over again as desired.

* The study of benzene can be used to bring out the typical reactions which can be expected to occur on the ring or nucleus of any cyclic compound. It also provides the basis for study of naming customs. Then as the study progresses to derivatives, the student's attention should be directed to the distinction between reaction on the nucleus and reactions on the side chains. She will find that she is already familiar with the latter because of her study in Unit II. A similar relationship holds for the study of nomenclature.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
(2) On the side chain d. Important uses 6. Condensed cyclics — naphthalene and phenanthrene 7. Aromatic alcohols and phenols a. Differentiated	
b. Aromatic alcohols* (1) Compared with alcohols studied previously (2) Benzyl alcohol (a) Formula — the benzyl radical (b) Preparation from aldehyde (c) Oxidation (d) Reaction to make esters	* This study should bring out the similarity of these compounds to alcohols studied previously. It is essentially review.
c. Phenols** (1) Typical phenols with formulas (2) Chemical behavior (a) As acids (b) To make esters (3) Solubilities (4) Phenol or carbolic acid (a) Source (b) Uses in disinfection industrially (c) Toxicology (5) Other common phenols — cresols, resorcinol, hexylresorcinol, naphthols, thymol, picric acid For each: (a) Formulas and names (b) Uses — particularly as disinfectants	** The phenols represent a new type of compound for the student and should be stressed accordingly. Their common action as disinfectants is the first instance so far presented of chemically related compounds, the use of which in nursing is based on common action. It also provides an opportunity to point out how common action may be modified by modification of chemical structure.

OUTLINE OF CONTENT

      (6) Bactericidal activity of phenols
        (a) In general
        (b) The phenol coefficient — its significance
        (c) Reaction with proteins
        (d) Modifications affecting bactericidal efficiency
8. Aromatic amines
   a. Aniline (aminobenzene)
      (1) Formula representation
      (2) Preparation
      (3) As a nitrogen base
      (4) Important uses
      (5) Physiological effect
   b. Aniline derivatives
      (1) Para-aminophenol—by oxidation of aniline
      (2) Acetanilide
        (a) Relation to aniline
        (b) Uses
        (c) Physiological effect
      (3) Sulfanilamide
   c. Azo dyes
      (1) The azo group
      (2) Typical examples — formulas and uses
        (a) Methyl orange
        (b) Scarlet red
        (c) Prontosil
9. Aldehydes, ketones, and quinones
   a. Aldehydes
      (1) Examples with formulas
      (2) Similiarity to aliphatic aldehydes

SUGGESTED DEVELOPMENT

An interesting exhibit of aniline derivatives encountered in the hospital as dyes or drugs might be prepared.

The physiological action of this group of compounds can be studied with interest both from the standpoint of commonly used medications and because of industrial hazards encountered by workers in industries where aniline derivatives are used.

As with the alcohols, the study of aromatic aldehydes and ketones is largely a review of the studies in Unit II.

Laboratory

Solubilities of hydrocarbons and phenols, especially those used in the hospital; inflammability of hydrocarbons; reactions with benzene to illustrate reactions on the ring structure; reaction of phenols with proteins, using phenol and other compounds of this class in hospital use. Reactions of acids, typified by making methyl salicylate and acetylsalicylic acid.

OUTLINE OF CONTENT *SUGGESTED DEVELOPMENT*

- (3) Benzaldehyde
  - (a) Preparation
  - (b) Chemical reactions
    - oxidation
    - reduction
- (4) Occurrence in nature

b. Ketones and quinones
- (1) Examples with formulas
- (2) Differentiated
- (3) Vitamin K — a quinone

10. Aromatic acids and derivatives
    - a. Examples with formulas — carboxyl group
    - b. Reaction expectations as acids
    - c. Acids of medicinal interest
      - (1) Benzoic acid
        - (a) Preparation possibilities
        - (b) Use as a preservative
      - (2) Phthalic acid
        - (a) Formula
        - (b) Phenolphthalein dyes — examples and uses
      - (3) Mandelic acid
      - (4) Salicylic acid
        - (a) Formula
        - (b) Derivatives of medicinal interest

11. Complex cyclic compounds — each ring structure, each substituent side chain exhibits its own peculiar behavior

OUTLINE OF CONTENT

B. Heterocyclic compounds

1. Heterocyclic defined
2. Contributing elements
3. Heterocyclics — derivatives of physiological importance
   a. Pyridine derivatives
      (1) The pyridine nucleus
      (2) Nicotinic acid—structure and function
      (3) Vitamin B_6 (pyridoxine) structure and function
   b. Pyrimidine derivatives
      (1) The pyrimidine nucleus
      (2) From nucleoproteins
      (3) Thiamine chloride — structure and function
   c. Pyrrole derivatives
      (1) The pyrrole structure
      (2) In hemoglobin
      (3) In chlorophyll
4. The alkaloids
   a. Alkaloid defined
   b. Examples with formulas
   c. As nitrogen bases — react with acids
      (1) Soluble salts used for medication
      (2) Insoluble tannates

SUGGESTED DEVELOPMENT

Lecture and discussion

The purpose of this study is to introduce the students to a few of the heterocyclic structures which they will meet again in the course of study. This selection can readily be extended or varied. The aim is not to reproduce these structures from memory but to be able to recognize them, as the need arises, by names and formula.

If time permits, chemistry involved in incompatibilities of alkaloids might be considered.

C. Chemically related drugs with similar physiological effects

1. Physiological action related to chemical structure
2. Modification of drug structure
   a. To increase desired effects
   b. To reduce toxicity or undesired side action
3. Comparative study of related drugs*
   a. Structural formulas to show:

Charts and blackboard diagrams can be used to focus the attention of the class on chemical similarities of related drugs.

The purpose of this study is less to acquire specific information concerning these drugs than to introduce the students to a method for studying related drugs.

* The following selection suggests groups of drugs that already may be more or less familiar to the class,

OUTLINE OF CONTENT

        - (1) The common structure
        - (2) Significant differences
    - b. Common physiological effects and uses
    - c. Significant modifications in action related to changes in structure

D. Chemotherapy

- 1. History — Ehrlich's theory
- 2. The problem of attack on microorganism with minimum toxicity for host
- 3. Arsphenamine and neoarsphenamine — compared as to structure and action, effect of modification
- 4. Antimalarials
    - a. Quinine — history and synthesis
    - b. Synthetic substitutes
- 5. Sulfanilamide and derivatives
    - a. History
    - b. The bactericidal agent — theory of action
    - c. Some important derivatives
        - (1) The common structural group
        - (2) Significant modifications — with emphasis on facts relating to nursing.

SUGGESTED DEVELOPMENT

either because of their popular use or because of interest:

1. The salicylates
2. Analgesic antipyretics
    - a. Aniline derivatives
    - b. Pyrazolone derivatives
3. The barbiturates*
4. The morphine group

* The barbiturates are not regarded as cyclics, although their formulas suggest this. They are, however, a particularly interesting group for comparative study.

The expectation is that, with this start, the students will be able to continue such study in the course in pharmacology. It will be an aid to classification, also, for the recognition of new drugs and groups to which they may be related.

SUGGESTIONS FOR STUDY AND DISCUSSION

Carbocyclic compounds

1. Prepare a chart, using both structural formulas and names, showing:
    - a. Important carbocyclic compounds obtained from coal tar.
    - b. A number of derivatives of these compounds which are used either as drugs or disinfectants.

2. a. Summarize the characteristic properties of benzene, noting especially any outstanding points of difference between its behavior and that of the aliphatic hydrocarbons.
   b. In what respects does benzene behave like the unsaturated hydrocarbons (as suggested by the double bonds in its formula)? In what respect does it differ from these compounds?

3. In general, which appears to be the more active chemically — the nucleus of a cyclic compound or the side chain? What is the basis for your answer?

4. a. Represent by a series of reaction equations the sequence of reactions involved proceeding from benzene to benzoic acid. Name all organic compounds.
   b. Compare this with the similar series from hexane to caproic acid. What similarities do you find? Also note points of difference.

5. Consult a reference book on organic chemistry and list some of the industries in which benzene is used. To what health hazards may workers in such industries be exposed?

6. a. With what classes of compounds will carbocyclic hydrocarbons form solutions?
   b. What are the solubilities of phenol?
   c. Account for any differences shown by phenol.

7. For either phenol or a cresol preparation spilled on the skin, immediate washing with ethyl alcohol is recommended. How does alcohol function?

8. Lysol, a well-known propriatory disinfectant, is a mixture of the three cresols.

   a. Assemble structural formulas for these three cresols and distinguish them by names.
   b. Would you expect these compounds to be more or less soluble in water than the compound phenol? Reason.
   c. What is the purpose of mixing cresols with soap, as is done in many of the commercial cresol disinfectants?

9. When, by whom, and for what purpose was phenol first used as a germicide? Under what name was it then known? What are the disadvantages of this compound as a disinfectant?

10. Thymol, the active principle of oil of thyme, has the chemical name: 1-methyl-3-hydroxy-4-isopropyl benzene.

    a. Assemble the structural formula for thymol.
    b. This compound is credited with antiseptic action. Why might this be expected, judging from its formula?

11. Assemble structural formulas for: (a) 2, 4-dinitrophenol, (b) 2, 4, 6-trinitrophenol. What is the common name for the latter? For what is it used?

12. a. How is the germicidal action of a phenol affected by a hydrocarbon radical as a substituent on the ring? How is it affected by introduction of a second hydroxyl?
    b. Assemble structural formulas for each of the following: phenol, cresol, resorcinol, and hexylresorcinol.
    c. What is your anticipation as to the comparative bactericidal effect of this series of phenols? Check the accuracy of your reasoned expectations by looking up the phenol coefficient for each. (Make sure that you know what is meant by the term "phenol coefficient.")

13. a. Assemble the structural formula for aminobenzene. What is the common name of this compound?
    b. In what industries is this compound used?
    c. What is the physiological action of this compound?
    d. What are some of the health hazards for workers in industries where this compound is used?

14. a. Compare the formulas for acetanilide and phenacetin with that of aniline. What similarity is evident?
    b. What therapeutic use is made of acetanilide and phenacetin?
    c. Compare aniline and acetanilide as to toxicity; compare acetanilide and phenacetin as to toxicity. (If necessary, consult a pharmacology for information.)

15. Consult textbooks in either organic chemistry or pharmacology for typical aniline dyes used for medicinal purposes. Also note any which are used as bacterial stains.

16. It is claimed that any of the following can undergo hydrolysis within the body to make salicylic acid: sodium salicylate, methyl salicylate, phenyl salicylate, and acetylsalicylic acid.

    a. Represent these reactions by word and formula equations.
    b. What, if any, common names are used for these compounds?

17. Locate the structural formula for vitamin K.

    a. Judged from its structure, should this compound belong to the water-soluble or the fat-soluble group? Reason.. What is its natural source?
    b. What carbocyclic nucleus do you find in this compound? Why is it classed as a quinone?
    c. What is the physiological function of vitamin K?

Heterocyclic compounds

1. a. List the common vitamins and look up their formulas. Which of these compounds contain heterocyclic structures?
   b. Locate a list of amino acids, products of hydrolysis of proteins, and pick out from this list any which contain heterocyclic structures.
2. a. Why is morphine classed among the heterocyclics? Why as an alkaloid?
   b. What is the advantage of morphine sulfate over the alkaloid morphine for medicinal use? How is morphine sulfate made from morphine?

Drugs and chemotherapy

1. a. Locate each of the following structures in the formula for the morphine molecule:
      (1) Phenanthrane nucleus.
      (2) The characteristic alkaloid group.
      (3) The alcohol group.
      (4) The phenol group.
   b. What common physiological effect is associated with morphine and its derivatives?
   c. What is claimed to be the effect of introducing a methyl radical at the phenol group? Is this consistent with factual experience in the use of codeine (methylmorphine) by comparison with morphine? Consult a textbook on pharmacology.
2. a. What physiological action is common to all of the barbiturates? For what purpose are these compounds usually used?
   b. What is claimed to be the effect of the length of the alkyl hydrocarbon radical on the physiological action of a barbiturate?
   c. What is the advantage of the sodium salts over the corresponding barbiturates?
   d. Contrast barbital, (diethylbarbituric acid) with amytal (isoamylethylbarbiturate) from the standpoint of duration of action.
3. What is the history of the compound arsphenamine? What is the significance of the name "salvarsan" applied to this compound? What are the advantages of neoarsphenamine, and what number does this compound have in Ehrlich's series?
4. a. Look up the history of the sulfa drugs. What was the first member of this group to be used for bactericidal effect? When was it first used? What chemical property exhibited by this compound suggested its possible action as a germicide? To what part of these compounds is the common action now attributed?
   b. How, theoretically, is the common bacteriostatic action of the sulfa drugs accounted for?

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Unit V

PROTEINS — THEIR NATURE AND PECULIAR IMPORTANCE IN THE LIFE OF THE ORGANISM — 4 TO 6 HOURS

Major objective of the unit. To develop an understanding of the nature and chemical behavior of proteins as a basis for: (1) studying the reactions involved in their digestion and metabolism within the human body, and (2) understanding the action of germicides and other agents whose functioning depends upon reactions with proteins.

Overview. Proteins have long been recognized to have peculiar significance for living organisms. They are essential for the vital activities of all forms of life from the minute virus to the most complex plants and animals. The nurse's *first* interest in them is because of the indispensable part which proteins play in human nutrition, both for normal health and growth and for regeneration of tissue following injury. *Second,* and of almost equal importance from the standpoint of human welfare, is the functioning of germicidal agents for the destruction of microorganisms. These agents are frequently employed by the nurse, and intelligent use means that effective disinfection must be obtained without an accompanying disastrous attack upon the proteins of tissue cells. The emphasis of this unit has been directed to serve these two important nursing interests.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
A. **Introduction to proteins**	**Lecture-demonstration with discussion**
1. Biological importance	
a. Essential components of all living cells	
b. Contributing to enzymes and hormones	
2. Synthesis of proteins	
a. Within plant cells	
b. Within animal cells	

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*

3. Important protein-providing foods
4. Chemical composition
  a. Constituent elements
  b. Molecular weights
  c. Supposed structural features of protein molecules
    (1) Size and complexity of molecules
    (2) Variety of amino acids
    (3) Amino-carboxyl linkages
    (4) Reactive groups within protein molecules	

5. Amino acids contributing to proteins
  a. Representative amino acids — formulas noting important structural features
  b. Essential amino acids
	A well-prepared chart showing the most important amino acids is valuable for the class to refer to throughout this entire study.

6. Classification of proteins
  a. Simple proteins
  b. Conjugated proteins
  c. Derived proteins
  For each:
    (1) Basis for classification
    (2) Subclassifications	

B. Simple proteins
1. Physical characteristics
  a. Fibrous — contributing to structure
  b. Soluble proteins
    (1) Examples and occurrence
    (2) Colloidal condition — physiological importance	

2. Chemical behavior
  a. Denaturation of proteins
    (1) Characteristics of denatured protein
	Simple demonstrations can be used effectively to make this discussion more vivid.

OUTLINE OF CONTENT

- (2) By heat coagulation
  - (a) Applications
    - in cookery and cleaning
    - in disinfection
    - in burns
    - tests for albuminuria*
- (3) By ultraviolet rays, X-rays, shaking
- (4) By chemicals — acids, bases, alcohols, phenols

b. Hydrolysis of proteins
- (1) Conditions for hydrolysis
- (2) Series of reactions
- (3) Physiological importance

c. Amphoteric nature of proteins
- (1) Reaction as acids
- (2) Reaction as nitrogen bases

d. With certain acids to make insoluble salts
- (1) With nitric acid — test for albuminuria*
- (2) With tannic and picric acids
  - (a) The reaction involved
  - (b) In treatment of burns**
  - (c) Antiseptic action

e. Reactions with salts of heavy metals
- (1) The reaction involved
- (2) Attack upon living cells
  - (a) Caustic effect
  - (b) Bactericidal effect
- (3) Proteins as antidotes

SUGGESTED DEVELOPMENT

* In presenting the tests for albumin in urine, both the principle and the technique of the usual test can be explained. If a reagent other than nitric acid is being used in the hospital laboratory, that can be introduced and demonstrated. Later, these techniques will be used in the study of urine as a normal secretion.

** Some excellent discussions of this topic have appeared in current medical literature.

OUTLINE OF CONTENT

3. Reactions used in recognition of protein constituents*
   - a. Biuret
   - b. Millon
   - c. Xanthoproteic
   - d. Hopkins-Cole

     For each:
     - (1) Characteristics
     - (2) Significance

C. Important conjugated proteins

1. Nucleoproteins
   - a. Occurrence
   - b. Hydrolysis products
   - c. Virus proteins
2. Chromoproteins
   - a. Occurrence
   - b. Hydrolysis products
   - c. Physiological functions

SUGGESTED DEVELOPMENT

* Demonstration with discussion is suggested. Other tests used for recognition of specific amino acids could be included. This discussion might come in the laboratory period.

Laboratory

Decomposition of protein on heating, with recognition of element composition; coagulation by heat; reactions with tannic and picric acids, with salts of heavy metals; reactions used in recognition of protein constituents; nucleoprotein from yeast, and the reactions to provide evidence of its composition.

SUGGESTIONS FOR STUDY AND DISCUSSION

1. What evidence can you cite that many different kinds of proteins exist? Why, theoretically, should this be possible?
2. a. Assemble a structural formula for a hypothetical polypeptide molecule composed of eight different amino acids. Identify the following structures in your formula representation:
   - (1) A free amino group.
   - (2) A free carboxyl group.
   - (3) An amino-carboxyl linkage.

   b. Represent, diagrammatically, the hydrolysis of this polypeptide showing one or more dipeptides, tripeptides, and finally amino acids. Name each amino acid.
3. Glutathione is a glutamic-cysteine-glycine complex. Assemble a structural formula to represent this compound. What is the significance of *thio* in the name glutathione?
4. a. What is meant by the expression "essential amino acid"? (Consult Henry C. Sherman, *Chemistry of Food and Nutrition*, 7th ed. Tell briefly what type of experiment has been used to obtain evidence that certain of amino acids are essential.

   b. What difference was noted between deficiency in tryptophane and deficiency in lysine?

   c. What American chemist is the authority in this field?

5. Compare the following foods from the standpoint of their adequacy as sources of essential amino acids: beef, cream cheese, egg, gelatine, nuts, peas. (See Table 5 in Henry C. Sherman, *op. cit.*, pp. 56–57.)

6. a. Locate the structural formulas for thyroxine and adrenalin. From which amino acid does each appear to be derived?
   b. What substances have been obtained on hydrolysis of insulin? What does this suggest concerning its classification as a compound?

7. a. What varieties of protein are found in each of the following locations: muscle cells, blood plasma, blood cells, skin?
   b. Of what physiological importance is it that albumins and globulins form colloidal rather than true solution?

8. From the standpoint of the protein involved:
   a. What difference in procedure would you follow in the treatment of the meat in preparing (1) a stew, (2) a pot roast? Give reasons.
   b. How does beaten egg white function as a stiffening agent? What has happened to the protein?

9. What procedure would you follow in removing a blood stain? Give reasoning.

10. Account for the disinfectant action of each of the following: (a) alcohol, (b) boiling water, (c) cresol, (d) mercuric chloride, (e) picric acid.

11. The effectiveness of mercury compounds has been found to vary with the dilution of the antiseptic solution and with the presence of blood or mucous secretions. Account for these findings on the basis of your knowledge of chemistry.

12. a. Account for the use of the silver nitrate pencil for the destruction of necrotic tissue.
    b. How is the bactericidal action of the various silver proteinate compounds accounted for? Why are these compounds preferred to silver nitrate for use on mucous membranes?

13. How does tannic acid function in the treatment of burns?

14. When nitric acid comes in contact with the skin, a yellow stain results. Account for this. What information is provided concerning the composition of skin proteins?

15. a. Which of the various protein reactions studied are suitable for detecting albumin in urine? For each, what is the nature of the reaction in which the protein is involved? Explain the purpose of any of the associated techniques which must be observed in order to obtain reliable results.
    b. What reaction on the part of Millon's reagent makes it unsuitable for this use?

16. A sample of egg albumen gave the following results on testing in the laboratory. Positive reactions were obtained with each of the following tests: biuret, Millon's, xanthoproteic, Hopkins-Cole. When thoroughly dried and decomposed, the escaping vapor reacted with red litmus to make blue litmus and with lead acetate paper to produce a dark-brown stain.
    a. Summarize the information provided by these tests as to the composition of this material.
    b. If these results were obtained with an unknown material, would you be sure that you were dealing with a protein? Give the reason for your answer.

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Unit VI

VITAMINS (AN OPTIONAL STUDY) — 3 HOURS

Major objective of the unit. To become better acquainted with the various compounds known as vitamins, particularly with relation to their chemical natures, the prevention of loss or destruction of vitamins during storage and preparation of foods, and their functioning in human metabolism.

Overview. If the time alloted to the chemistry course is generous enough to provide for more than basic essentials, a study of the chemistry of vitamins as a separate unit is justifiable. For the shorter course, it is recommended that the various vitamins be considered in connection with the metabolic reactions in which they are known or believed to function, but that the more inclusive study of these compounds be left to the courses in nutrition and pharmacology.

The emphasis in this unit is placed on chemistry. The signs and symptoms of deficiency, as well as other factors relating to dietary treatment and nursing care, have been left for development in subsequent courses. This will probably be the first place in the nursing curriculum where the students encounter a study of vitamins. It is for this reason that the history of the various vitamins is suggested for inclusion; this history provides a logical and most interesting approach to the study of these compounds. Only vitamins whose functioning has been well established have been included in this short unit.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
A. **The vitamins** 1. Vitamin defined 2. A heterogeneous group a. Chemically b. As to physiological function	**Lecture with discussion** It is suggested that the emphasis be placed on study of vitamins as organic compounds. From study of the structural formulas, the student should, with a minimum of guidance, be able to draw her own conclusions regarding: 1. Solubilities 2. Group relationship 3. Susceptibility to oxidation
B. **The fat-soluble vitamins — A, E, D, K — for each member of this group** 1. History 2. Occurrence in nature (of vitamin or provitamin) 3. Structural features stressing: a. Important similarities (within each vitamin group) b. Chemical nature in relation to solubilities c. Oxidation possibilities	The teacher should be in a position, from her more advanced study, to verify and produce authoritative references with relation to the student's reasoning.
4. Destruction on oxidation a. Favoring conditions b. In relation to food storage or cooking 5. In relation to physiology a. Absorption, storage, and elimination b. Important known functioning 6. Normal nutritional requirement and international units	It should be possible for the group to form some definite conclusions, based on reasoning and authoritative references, relating to desirable practice in selection, care, and preparation of food.
Special considerations Vitamin A a. Activation of provitamin b. Color in relation to foods c. Physiological functioning (1) In retinal cycle (2) In epithelial tissue Vitamin-D group a. Activation of provitamin b. Antirachitic functioning (1) Relation to absorp-	Limit the study of physiological importance to major functions. Place emphasis on functioning which relates definitely to studies that will be developed subsequently in the chemistry course, for instance — vitamin D in relation to calcium and phosphorus metabolism.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
tion of calcium and phosphate ions (2) Relation to bone formation Vitamin E (tocopherols) a. Physiological importance (1) In muscle metabolism (2) In reproduction Vitamin-K group a. Synthesis in intestine b. Absorption influenced by bile salts c. Relation to prothrombin activity	
C. Water-soluble vitamins 1. Ascorbic acid (vitamin C) a. History b. Occurrence in nature c. Chemical structure d. Oxidation (1) Favoring conditions (2) In relation to storage and cooking e. Physiological importance (1) In carbohydrates and protein metabolism (2) Development of teeth f. Nutritional requirement and international unit. 2. The vitamin-B complex a. History b. Important members c. Essential components of all living cells	
For each member of this group 1. Important food sources 2. Chemical structure 3. Stability in relation to a. Heat and light b. *p*H of environment c. Destruction in cooking	A good opportunity is afforded for discussion of common methods of cooking with relation to loss of vitamins.
4. Physiological importance 5. Nutritional requirement	The physiological importance can only be suggested at this time, but

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
Special considerations Thiamine chloride a. In cocarboxylase enzyme b. Importance in carbohydrate metabolism c. Synthesis in intestine	the importance of enzymes, coenzymes, and oxidation-reduction systems should take on meaning as the course proceeds
Riboflavin (vitamin B_2 or G) a. Characteristic flavin color b. In yellow oxidation enzyme c. Importance in cellular oxization-reduction system	
Niacin (nicotinic acid) a. Pellagra preventing factor b. Constituent of cozymase molecule — functioning in oxidation-reduction system	
p-Aminobenzoic acid a. An essential metabolite for microorganisms b. Antagonistic to sulfanilamide — effect on intestinal flora — effect on vitamin synthesis	Refer back to study in Unit IV. This topic should be followed through later in the microbiology course.

SUGGESTIONS FOR STUDY AND DISCUSSION

1. Examine the formulas of the various fat-soluble vitamins.
   a. Why should you expect these compounds to be soluble in fats but not in water?
   b. What suggestions do you find in any of these formulas that the compound should be subject to oxidation?
2. Make note of the natural occurrence of vitamins A, D, E, and K. What relationship do you find between occurrence and solubility?
3. It is claimed that the use of mineral oil as a cathartic interferes with the absorption of vitamins. Is this objection reasonable? Explain.
4. What is a provitamin? Give specific examples.
5. Account for the fact that sunlight has proved to be beneficial in the prevention and treatment of rickets.

6. Summarize the findings as to physiological functioning of the vitamin-E group as reported by K. Hickman, "Fat-Soluble Vitamins," *Annual Review of Biochemistry*, Vol. 12, 1943, pp. 377–384.
7. a. What relationship exists between vitamin-K intake and the prothrombin level of the blood? Of what significance is this? What is the relationship between bile salts and the utilization of vitamin K provided in the diet?
   b. Why is the provision of vitamin K especially important for the newborn infant? (See K. Hickman, *op. cit.*, p. 386.)
8. How would rancidity of a fat be likely to affect its vitamin value? Explain.
9. If neither citrus fruits nor tomatoes were available, what other foods might be chosen as good sources of ascorbic acid?
10. In general, which will be richest in vitamin C: raw tomatoes, stewed tomatoes, or commercial canned tomatoes? Reason.
11. Recall the physical and chemical properties of the various water-soluble vitamins. Mention some common practices in cookery which result in destruction or loss of any of these vitamins. What practices do you advocate to diminish such losses?
12. What special biological significance makes the vitamin-B group of importance? (See Roger J. Williams, "Water-Soluble Vitamins," *Annual Review of Biochemistry*, Vol. 12, 1943, p. 308.)
13. To what enzyme systems do various members of the vitamin-B group contribute? In general, in what types of reactions do these enzymes function? What does this suggest concerning the general physiological effect of this vitamin group?
14. Locate the formula for thiamine. Why should this compound be expected to react with acids to form salts? Assemble the equation for the reaction of thiamine with hydrochloric acid to make thiamine chloride. What is the advantage of the salt over thiamine?
15. Account for the increased demand for thiamine whenever metabolism is increased, as in fever, vigorous exercise, or hyperthyroidism?
16. Why are whole-wheat flours richer in vitamin content than refined white flour? Which vitamins are affected? What measures have been adopted to compensate for this?
17. Which of the vitamins appear to be important for normal tooth development? What functioning is attributed to each?
18. Bottles containing vitamin capsules frequently carry the instruction, "Keep in a cool place." Which of the vitamins are most likely to be destroyed if this direction is ignored? Explain.

19. Mention one way in which vitamin absorption is affected by oral administration of sulfanilamide compounds. Which vitamins?
20. From the standpoint of vitamin involvement, how are the sulfanilamide compounds believed to exert their bacteriostatic effect?

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Unit VII

A STUDY OF DIGESTION WITH SPECIAL CONSIDERATION OF ENZYMES — 6 TO 9 HOURS

Major objective of the unit. To acquire an understanding of the process of digestion, with special attention to chemical phases and enzyme action; to help the student to recognize how this knowledge can be used as a basis for good food habits and for more intelligent understanding of digestive disturbances associated with illness.

Overview. Knowledge of the process of digestion as a normal physiological process is important for the nurse because normal digestion is essential for the well-nourished, healthy individual. Digestive disturbances, minor and major, are frequent accompaniments of illness. Moreover, misconceptions and unscientific ideas relating to the digestive processes are prevalent among the general public and contribute to habits which are not consistent with the best level of health. Both as a teacher and in the actual care of the sick, the nurse has need for good scientific information concerning the processes of digestion.

The emphasis of the chemistry course is on the chemistry of digestion, supplementing rather than duplicating the study of this process in the course in anatomy and physiology. It would be decidedly advantageous to the student to have the two courses so planned that the study of digestion could be treated as a unit, either through correlation with relation to time or breaking down the boundaries completely between the two courses.

In entering upon the study of physiological chemistry, students will find that the complexity of the situation has increased. They may discover from firsthand experience that it is more difficult to obtain consistent results in the laboratory when using saliva, or extracts of animal secretions, than when their work involved only the ordinary laboratory reagents. It is important for them to recognize some of the difficulties which scientists have encountered in studying reactions going on in a living animal; also to understand the reason for the existence of greater uncertainty as to exact facts and the tentative nature of explanations which may be advanced. To a much greater extent than previously, documentary evidence must be accepted in the place of firsthand observation. The teacher may need to guide the thinking of the class in this direction.

OUTLINE OF CONTENT

A. **Enzymes and their functioning**
   1. What is an enzyme
   2. Distribution in nature
   3. Classification according to function:
      a. In hydrolysis
      b. In oxidation-reduction
   4. Enzymes as catalysts
   5. Specificity of enzyme action
   6. Chemical nature
      a. Evidence of protein nature
      b. Prosthetic group
      c. Instability
   7. Factors affecting enzyme functioning.
      a. Concentration of enzyme
      b. Hydrogen-ion concentration
      c. Temperature
      d. Accumulation of products
      e. Activators
         (1) Specific ions
         (2) Kinases
      f. Enzyme poisons
   8. Zymogens and zymases

SUGGESTED DEVELOPMENT

A. **Lecture and discussion** to introduce, supplement, and summarize findings of laboratory study.

Laboratory

Study might be made of various factors affecting enzyme action using sucrase obtained from yeast. However, one of the most interesting studies is that made individually by each student working with her own saliva. During a two-hour laboratory period, each of the factors influencing enzyme action can be illustrated. Individual differences in ptyalin activity will also be observed.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
9. Coenzymes a. Meaning b. Suggested functioning 10. Digestive enzymes — their functioning	
B. **The chemistry of digestion** 1. The function of digestion a. Digestion defined b. Why necessary 2. Chemical reaction favored by physical processes a. Provisions for large surface of contact b. Provisions for continuous removal of products	B. **Lecture and discussion** to introduce, supplement, and summarize laboratory study.
3. Salivary digestion a. Saliva (1) Source (2) Composition (3) Hydrogen-ion concentration (4) Enzyme component b. Physical processes and their functioning c. Chemical reaction (1) The reaction involved (2) Functioning of ptyalin (3) Conditions favoring reaction (4) Continuation in stomach	In this study, the laboratory work may be made the center of attention. Before the students begin their individual studies of salivary digestion, the lecture and accompanying discussion should have provided the background necessary for attacking the laboratory work with understanding. Then, when the laboratory work has been completed, there should be an opportunity to discuss the students' findings and any problems which were encountered, such as results inconsistent with those reported in the literature.
4. Gastric digestion a. The gastric secretion (1) Stimulation — psychic and chemical (2) Composition (3) Enzyme components (4) Hydrochloric acid (a) Its functions (b) Theories as to origin	This study should yield findings which can be interpreted in terms of good and bad habits in eating.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
b. The digestive reactions (1) Of proteins (2) Of fats For each (a) Reactions involved (b) Enzyme functioning (c) Favoring conditions c. Physical factors in relation to chemical digestion	
5. Intestinal digestion a. Pancreatic secretion (1) Stimulation (2) Enzyme components (3) Hydrogen-ion concentration b. Intestinal secretion (1) Enzyme components (2) Hydrogen-ion concentration	This study provides an opportunity to point out the increasing difficulty encountered in the study of reactions of physiological interest as the area to be investigated becomes less readily accessible to the worker.
c. Bile (1) Composition (a) Components functioning in digestion (b) Components for elimination (2) Functioning of various components d. Digestion of proteins (1) Reactions involved (2) Enzymes and conditions for enzyme action (3) Products for absorption e. Digestion of carbohydrates (1) Reactions involved (2) Enzymes and conditions for enzyme action	A weakness commonly noted is failure to make clear to the student the functioning of water, in hydrolysis. A common misconception is that enzymes react with the food substances.

OUTLINE OF CONTENT

- (3) Products for absorption
- f. Digestion of fats
  - (1) Reaction involved
  - (2) Enzyme
  - (3) Products for absorption
  - (4) Provision for emulsion — functioning of bile salts
- g. Summary of conditions along intestinal tract which favor completion of digestion
  - (1) To provide surface of contact
  - (2) To provide favoring *p*H for various enzymes
  - (3) Time
  - (4) Absorption of end products

6. Absorption from small intestine
   - a. Monosaccharides
     - (1) Pathway of absorption
     - (2) Supposed mechanism
   - b. Amino acids — pathway of absorption
   - c. Fatty acids and glycerol
     - (1) Pathways for each
     - (2) Functioning of bile salts
     - (3) Fat synthesis in intestinal membrane

7. Bacterial action in large intestine
   - a. On carbohydrates
   - b. On amino acids
   - c. Vitamin synthesis
   - d. Products for absorption
   - e. Composition of feces

SUGGESTED DEVELOPMENT

Laboratory

Study of saliva as a typical secretion, testing for protein, carbohydrate, various ions, and *p*H. Follow the sequence of salivary digestion of starch, using iodine and Benedict's reagent. Optimum hydrogen-ion concentration for ptyalin activity.

Gastric digestion of protein, using commercial pepsin.

Digestion of starch, protein, and fat, using commercial pancreatin.

Study of bile, testing for ion components, *p*H, bile salts.

SUGGESTIONS FOR STUDY AND DISCUSSION

Enzymes

1. Where are enzymes distributed in nature? Mention some specific examples and suggest their functioning.
2. What is a catalyst? Summarize briefly experimental evidence, cited by authorities, that enzymes are catalysts. Cite evidence, drawn from your own experience, which indicates their catalytic functioning.
3. How would the action of the enzyme be affected by each of the following:
   a. Increase in temperature from 20 to 30° C.
   b. Increase in temperature from 20 to 50° C.
   c. Increase in temperature from 20 to 80° C.
   d. Transfer from room temperature to the refrigerator.

   Make a summary statement as to the effect of changes in temperature on enzyme action.
4. What changes in speed of reaction would you expect, in the course of time, in a test tube containing cooked starch and ptyalin, maintained under constant temperature? Account for the various changes which you describe.
5. What is meant by the statement that enzymes are specific in their action? Cite experimental evidence from your own laboratory experience which suggests this to be the case.
6. Mention two methods which might be used in the laboratory to check enzyme activity.
7. Suggest a possible relationship between enzyme action and the bactericidal effect of mercury salts.
8. a. In making leavened bread, some breadmakers allow the dough to rise overnight, others plan for a shorter period of only 1 to 2 hours. What difference in recipe procedure makes the latter possible? Explain in terms of enzyme activity.
   b. What temperature conditions must be provided for successful leavening of the dough? How is the reaction finally stopped? Explain in terms of enzyme functioning.

The chemistry of digestion

1. What is hydrolysis? Assemble word and formula equations to illustrate the fact that digestion of starch involves a series of hydrolytic reactions catalyzed by enzymes.
2. Compare the *p*H of whole saliva with that which is optimum for salivary digestion. How are conditions optimum for ptyalin activity provided? In what part of the digestive tract? How is ptyalin activity finally stopped?

3. What effect would each of the following probably have on the speed of digestive reactions:
   a. Hasty bolting of food.
   b. A warm beverage with the meal.
   c. Ice water with the meal.
   d. A large quantity of water with the meal.
   e. Sluggish peristalsis along alimentary tract.
   Give reasons for your answers.

4. Illustrate the effects of changing hydrogen-ion concentration with relation to enzyme action by reference to the functioning and fate of pepsin in the course of normal digestion.

5. Assemble word equations for the reactions involved in the clotting of milk in the course of gastric digestion. Mention the functioning enzyme. What name is given to the insoluble compound thus made? Where is a similar reaction encountered in food preparation?

6. a. Assemble the word equation for the reaction involved in gastric digestion of protein.
   b. What is the essential function of hydrochloric acid in this digestive process?
   c. Comment, in this connection, on the indiscriminate use of sodium bicarbonate to relieve gastric distress.

7. a. Assemble the equation representing the digestion of stearin, a typical fat.
   b. How does the emulsification of fats function to favor digestion? What provision is made by nature for emulsification along the intestinal tract?
   c. What is the advantage, from the standpoint of digestion, of a mixed meal over one excessively high in fat?

8. Any interference with the passage of bile into the intestine also interferes with the digestion and absorption of fat. Account for this. In what pathological condition is a low fat diet often prescribed for this reason?

9. Indicate how conditions which provide hydrogen-ion concentrations favorable to the functioning of each of the various enzymes may be provided along the intestinal tract.

10. What is the function of cellulose in the food? Is there any provision for chemical reaction with cellulose along the human digestive tract? Explain.

11. List the various components which might be expected in the fecal mass of a person on an ordinary mixed diet.

12. Prepare a chart in which you summarize the digestive reactions along the entire digestive tract, showing the functioning enzymes, the various provisions — physical and chemical — which favor digestion, and the end products and their paths of absorption.

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Benjamin Harrow, *Textbook of Biochemistry*, 4th ed., Philadelphia, W. B. Saunders Company, 1946, Chaps. X, XII.

(T) Philip B. Hawk, Bernard L. Oser and William H. Summerson, *Practical Physiological Chemistry*, 12th ed., Philadelphia, The Blakiston Company, 1947, Chaps. XII–XXI (especially for laboratory work).

Philip H. Mitchell, *A Textbook of Biochemistry*, New York, McGraw-Hill Book Company, Inc., 1946, Chaps. VII–IX.

Henry C. Sherman, *Chemistry of Food and Nutrition*, 7th ed., New York, The Macmillan Company, 1946, Chap. VI.

Roger J. Williams, *A Textbook of Biochemistry*, New York, D. Van Nostrand Company, Inc., 1942, Chaps. IX, XVI–XVII.

Unit VIII

METABOLIC REACTIONS — THE FUNCTIONING AND FATE OF OXYGEN, GLUCOSE, FATS, AND PROTEINS WITHIN THE CELLS — 10 TO 15 HOURS

Major objectives of the unit. To acquire a knowledge of normal metabolic reactions and their significance in relation to health. To use this knowledge as a basis for understanding the principles of nutrition, and the significance of metabolism tests, commonly used laboratory tests, and some of the deviations from normal metabolism frequently encountered in nursing.

Overview. The emphasis of this unit is on *normal metabolism.* It should contribute directly to the study of physiology and nutrition and serve as a background for the subsequent study of pathological conditions encountered in care of the sick. Deviations from normal, i.e., pathological chemistry, are considered only when they function to provide better understanding of normal processes. The chemistry relating to pathology will have greater meaning for the nurse if studied when she is actually caring for the sick; consequently, it is advised that this phase of the study be developed more fully in its natural setting — in the "Introduction to Medical Science" and in instruction in clinical nursing.

The study of this unit provides an opportunity to develop an appreciation on the part of the student of the difficulties encountered by those who undertake investigations of conditions within living cells, and of the tentative nature of much of the knowledge which guides even the best medical practice. This should help the student to realize the necessity for continued reading and study in order to understand changes in nursing practice which accompany new developments in medicine.

A review topic. Study of the physiological functioning of oxygen and its relation to energy production forms a natural part of the study of metabolism. The topic, "Commercial Supplies of Oxygen," which presumably was included in the general chemistry course, is here reviewed[1] with emphasis on therapeutic use and on precautions to be observed in connection with this use.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
A. **Introduction**	**Lecture and discussion**
1. Difficulties inherent to investigations in this area 2. Methods of study — past and present 3. Metabolism defined	A few leading questions often bring to the surface popular misconceptions relating to metabolism, and open the area for study.
B. **Oxygen — its vital function**	
1. History* — discovery and early studies of physiological interest 2. Important properties of oxygen (reviewed) in relation to its physiological functioning 3. The demand for oxygen associated with need for energy production	* Priestley's firsthand account of the first "oxygen inhalation," also Lavoisier's study of animal heat, are suggested as of special interest and historic importance.
a. Oxygen as a source of chemical energy**	** See Albert P. Mathews, *Principles of Biochemistry*, Baltimore, William Wood & Company, 1936, pp. 490–491, for an excellent statement on this point.
b. Absorption and transportation to cells***	*** To be developed in detail in Unit IX.
c. Oxygen as a partner for glucose, fats, and proteins (1) The all-inclusive reaction**** — matter and energy transformations (a) Matter products (b) Energy products (c) Quantitative relations (d) Respiratory quotients	**** The study of the intermediate steps in metabolism comes later in this unit. This study presents the comparative energy relationship. Too often the emphasis is on the foods, ignoring oxygen, the necessary partner in energy production.

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[1] See discussion Chap. III, p. 80.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
(2) Varieties of energy produced within living cells	
(3) What becomes of the products	
4. Commercial supplies of oxygen to meet living needs*	* If possible, provide opportunities for each student to observe oxygen therapy in use.
a. When required	
(1) In general	
(2) Therapeutic uses — and the principles involved	
b. The fire hazard associated with their use	Demonstration (or laboratory study) to illustrate effect of oxygen concentration on burning
C. Measurement of energy product	
1. Law of conservation of energy	
2. The possibility of measuring energy	
3. The calorie as a measuring unit	
4. Methods for measuring energy products	
a. Direct — use of calorimeter	
b. Indirect — as measurement of oxygen intake or carbon dioxide output	
(1) The quantitative relations	
(2) Method used in institution**	** **Laboratory** preceded or followed by discussion. When facilities permit, a laboratory period would be profitably expended in demonstration of the basal metabolism test. It is suggested that a member of the class serve as the subject while the rest of the class make records, at the direction of the technician or instructor, of the data collected and used in computing results of such a test. A review of gas laws will be needed in this study.
D. Glucose and glycogen — their functioning and fate	
1. End products of carbohydrate digestion	
2. Transportation to cells — normal fluctuations in concentration in blood	
3. In the liver	
a. Glycogenesis	
(1) Experimental evidence	

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
(2) The catalyzed reaction	
b. Glycogenolysis	
c. Antagonistic action of insulin and adrenalin	
d. Function of liver in maintaining constant supply of glucose to cells	
4. Primary function of glucose — oxidation for production of energy a. End products of reaction b. Intermediate metabolism in muscle cells (1) Glycogen made from glucose (2) Functioning of phosphates (a) In production of energy for muscle contraction (b) In intermediate glycogen metabolism (3) Important intermediate reactions (4) Glycogen-lactic acid cycle (5) The functioning of oxygen (6) Enzyme systems — and vitamins involved c. Metabolism within nerve cells	It is suggested that only the more important and generally agreed upon intermediates be introduced into this discussion, thus simplifying the study.
5. Glucose used to make fats a. Experimental evidence b. Dietary significance	
6. Insulin and its functioning a. That which is known b. Theories as to functioning	
7. Lactose production in mammary glands	

OUTLINE OF CONTENT *SUGGESTED DEVELOPMENT*

E. **Fats — their functioning and fate**
  1. In the intestinal membrane — resynthesis
  2. Transportation to cells — routes
  3. In the liver
    a. Desaturization of fatty acids
    b. Production of short chain acids and ketones
  4. Fats and fat derivatives essential for cell structure
  5. Oxidation with production of energy
    a. Experimental evidence
    b. End products of reaction
    c. Supposed intermediate steps
      (1) Oxidation of glycerol
      (2) Oxidation of fatty acids
  6. Ketogenesis — interrelation of fat and glucose metabolism*
    a. Normal production of acetoacetic acid and β-hydroxybutyric acid in liver
    b. Ketosis
      (1) Occurrence
      (2) Associated acidosis
      (3) Theory accounting for excessive ketonemia
      (4) Therapeutic measures to reestablish carbohydrate metabolism
  7. Fat as a source of glucose
  8. Storage of fat
    a. Location of fat depots
    b. Various origins

* This is particularly important for understanding the diet and complications in diabetes; hence, it merits thorough treatment. The current scientific literature should be watched for new developments.

OUTLINE OF CONTENT

c. Metabolism within fat storage cells
d. Function of stored fat

9. Function of fat in lactation

10. Phospholipids — as fat derivatives
    a. Occurrence
    b. Supposed functioning

F. **Proteins and amino acids — their functioning and fate**

1. Transportation of amino acids
2. Metabolism of tissue protein*
    a. The primary function
    b. Continuous interchange between blood and tissue proteins
        (1) Experimental evidence
        (2) Adjustments of tissue to changes in dietary level of protein
        (3) Adjustments from organ to organ during fasting
        (4) Adjustments of proteins of blood
            (a) Plasma proteins and hemoglobin
            (b) Antibody production
        (5) Protein reserves
3. Amino acids for synthesis of enzymes and hormones
4. Amino acids oxidized with production of energy
    a. End products of oxidation
    b. Intermediate steps in this metabolism
        (1) Deaminization
        (2) Synthesis of urea

SUGGESTED DEVELOPMENT

* In this area, also, the current literature should be watched for new developments. Some of these may be evident in the hospital, for instance in changes in relation to protein in diet, or use of products of protein hydrolysis intravenously. New developments often help to focus interest on important studies.

Supplementary reading

Carefully selected articles relating to new developments in any of these areas might be assigned to the class for outside reading. This reading might then be discussed in class. Guidance will be needed to enable the student to interpret with understanding material which is somewhat more difficult than her usual reading.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
(3) Oxidation of keto-organic acid (a) Typical aliphatic acid (b) Typical aromatic acid	**Laboratory** A study of components of muscle cells, including tests for ions, protein, carbohydrate, iron.
5. Metabolism of sulfur containing amino acids 6. Antiketogenic action of certain amino acids	A study of urine as a normal secretion,[1] including *p*H, tests for ions, reducing sugar, protein, and other components as time allows.
7. Metabolism of nucleoproteins 8. Creatine and creatinine a. Chemical relationship b. Synthesis from amino acids c. Occurrence in muscle d. Supposed functioning in metabolism	A urine specimen showing elimination of ketones might also be available through the hospital laboratory for use in this study.
G. **Summary — end products of metabolism and their pathways for elimination**	

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[1] It is suggested that study of the pathological aspects of urinanalysis be provided for in "Introduction to Medical Science."

SUGGESTIONS FOR STUDY AND DISCUSSION

For supplementary reading and class reports

The assignment, of special topics for study and report might be used advantageously in this unit. The reading assignment should not be too technical for the student to understand. On the other hand, it should be of such a nature as to merit thoughtful reading and to require analysis and organization by the student preparing the report. This provides experience in gathering information from scientific literature. It is also an opportunity for becoming acquainted with sources of information in books and professional magazines. The difficulty of the assignment can be adjusted to the preparation and ability of the individual to whom it is assigned. The following suggestions illustrate this point. They are graded in difficulty from the first assignment, which is relatively easy reading, to the last which is relatively difficult.

1. Account for the differences in the energy products obtained from 1 gram each of carbohydrates, fats, and proteins within the calorimeter and the

physiological energy values for these foods as used in the computations of diets. (Reference: Henry C. Sherman, *Chemistry of Food and Nutrition*, 7th ed., Chap. VIII.)

2. What is meant by the term "basal metabolism"? How have normal standards for basal metabolism been computed? Illustrate by computing your own normal caloric requirements to meet basal needs. (Reference: Henry C. Sherman, *op. cit.*, Chap. IX.)
3. What is the present-day belief as to the functioning of insulin in glucose metabolism? Consult the following sources; then summarize your findings. (References: Benjamin Harrow, *Textbook of Biochemistry*, 4th ed., pp. 314–317 and 493–496; Philip H. Mitchell, *A Textbook of Biochemistry*, pp. 396–398; Henry C. Sherman, *op. cit.*, p. 79; C. H. Best, "Physiology and Biochemistry," *Currents in Biochemical Research*, (David E. Green, ed.) New York, Interscience Publishers, Inc., 1946, Chap. XXVII.)
4. The theory as to the relationship of carbohydrate and fat metabolism is being revised in the light of recent studies. You will encounter both the old and the new theories in professional literature at present. Consult the references suggested below; then summarize your findings with relation to the following:

   a. Facts upon which both theories are based in common.
   b. The older theory to explain these facts.
   c. The new developments and consequent modifications in the theory.

   (References: Henry C. Sherman, *op. cit.*, pp. 117–118; Benjamin Harrow, *op. cit.*, pp. 341–342; Philip H. Mitchell, *op. cit.*, pp. 421–424; Michael Somogyi, "Carbohydrate Metabolism," *Annual Review of Biochemistry*, Vol. II, 1942, pp. 259–263; "Ketones as Fuel for Muscle Contraction" (editorial), *Journal of the American Medical Association*, Vol. 123, 1943, p. 771.)
5. Recent research with isotopic nitrogen has resulted in some significant changes in the concept of the maintenance of body protein. Contrast the older with the newer ideas, and summarize the information which you find in relation to protein reserves and their importance to the animal. (References: H. H. Mitchell, "The Metabolism of Proteins and Amino Acids," *Annual Review of Biochemistry*, Vol. 11, 1942, pp. 257–262, 276; H. Borsook and J. W. Dubnoff, "The Metabolism of Proteins and Amino Acids," *Annual Review of Biochemistry*, Vol. 12, 1943, pp. 183–189; Donald D. Van Slyke, "Physiology of Amino Acids," *Science*, Vol. 95, March 13, 1942, pp. 259–263.)

For class discussion

1. Why is measurement of oxygen consumption, as in metabolism studies, a reliable index of the energy expenditure for the period of measurement?

2. a. How can an increased proportion of oxygen in the inhaled air, as in oxygen therapy, affect the amount of oxygen carried by the blood to the cells?
   b. Account for the value of oxygen therapy in pneumonia.
   c. When a gaseous anesthetic is being administered, why is it necessary that oxygen as well as the anesthetic be supplied?

3. *Review:* What conditions are essential for a burning reaction? Explain why the conditions in an oxygen tent make necessary special precautions to prevent fire.

4. a. What are the primary functions of each of the following in normal metabolism?
   (1) oxygen (2) carbohydrates (3) fats (4) proteins.
   b. In what respects do carbohydrates, fats, and proteins appear to function interchangeably in normal metabolism?
   c. Why is it essential that a well-balanced diet provide all three of these important types of food?

5. How do the various members of the vitamin B-complex function, in general, in relation to metabolism? Illustrate specifically with reference to thiamine.

6. What is the function of liver glycogen? From what different substances can it be synthesized? What factors control the functioning of glycogen?

7. a. What is believed to be the immediate source of the energy for muscle contraction? For what purpose is the oxygen brought by the hemoglobin believed to be essential?
   b. Chart the sequence of generally accepted intermediate compounds from glycogen to pyruvic acid, using structural formulas. Note evidences of oxidation and reduction reactions in this sequence.
   c. Represent the reversible reaction possible between pyruvic acid and lactic acid.
   d. Why, perhaps, does lactic acid accumulate in the blood in higher concentrations during vigorous exercise than under conditions of moderate exercise? What becomes of this lactic acid?
   e. What are believed to be the functions of adenosine-triphosphate and phosphocreatine in carbohydrate metabolism?

8. Account for the special need of the diabetic for a carefully controlled balance between carbohydrate and fat in his diet. How does insulin function to make a well-balanced diet possible for the diabetic?

9. a. What is ketosis? Under what condition, in general, does it occur? What are the ketone bodies? What is their source? Where are they produced? Seemingly for what purpose? How can this condition be detected by laboratory test?

b. Mention three clinical conditions under which ketosis is known to occur. What similarity exists in all three? What differences exist among these three as to the underlying cause?

10. a. What is the function of fat deposits in the animal? From what food substances can this fat be made?
    b. Cite experimental evidence that animals can make fat from carbohydrate.
    c. Compare protein with carbohydrate as a possible source of storage fat. Of what significance is this in planning a reducing diet?

11. a. What standards for protein requirement are advocated by Sherman for (1) the growing child, (2) the healthy adult, (3) the aged? Discuss the basis for each of these recommendations in relation to metabolic needs.
    b. What provision does the body appear to make for protein reserves? Which organs respond quickly to changes in diet or demand for protein? Which respond slowly? In which organs is protein, apparently, conserved? Suggest how the body might adjust during a short fast by comparison with a period of starvation.
    c. In what respect does adequate protein help the body to resist infection?

12. List the various end products of the metabolism of carbohydrates, fats, proteins, and nucleoproteins which are continually entering the blood for excretion, and tell through what channels each is excreted.

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Unit IX

MAINTENANCE OF THE ENVIRONMENT FOR THE LIVING CELL — THE INTEGRATED FUNCTIONING OF BLOOD, LUNGS, AND KIDNEYS — 4 TO 8 HOURS

Major objectives of the unit. To develop an understanding and appreciation of the delicately adjusted, coordinated physiological processes whereby the blood provides the relatively constant environment essential for normal metabolism within living cells of the various tissues and organs. To learn how disturbances in one part of the body can provoke systematic responses; consequently, to provide the basis for understanding how treatments and nursing care can be directed to favor readjustment to normal conditions.

Overview. In the chemistry course outlined in the *Curriculum Guide*, a considerable portion of the content of this unit appears in the study entitled "The Physiological Importance of Salts and Their Ions" which is there suggested as an optional study. The outline has been expanded in the present study to include additional consideration of blood chemistry.

The emphasis is on the chemistry of blood, but it is impossible to consider this fluid tissue apart from the functioning of other parts of the body as well, since it serves as the medium of communication between various tissues and organs. As has been mentioned in connection with other units, this emphasis on chemistry should reinforce rather than duplicate the more comprehensive study in the course in "Anatomy and Physiology."

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
A. **Homeostasis***	**Lecture and discussion**
1. The major functions of blood 2. Interrelations of blood with other systems	* It is suggested that, in preparation for this study, both teacher and students refer to Walter B. Cannon,

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
B. Composition of blood 1. Cells — and their major functions 2. Plasma — important components a. For transportation b. Plasma proteins c. Electrolytes	*The Wisdom of the Body*, rev. ed., New York, W. W. Norton & Company, Inc., 1939, for his concept of homeostasis. This provides a good opening for the discussion and a concept to keep in mind throughout the study of the unit.
3. Proteins of the plasma* a. Albumins — function in control of osmotic pressure b. Globulins (1) Various types (2) Globulins and immunity c. Fibrinogen (1) Function in clotting (2) Fibrin foams and films — their uses d. Interchange between plasma and tissue proteins e. Regeneration of plasma protein	* The teacher will need to watch the current scientific literature for new information in this area. Some of the less technical articles might be suggested to the students as supplementary reading.
4. Clotting of blood a. To safeguard living cells b. Conditions for clotting c. The mechanism of clotting d. Anticoagulants — their action 5. Nonprotein nitrogen — components and their sources 6. Glucose a. Source and function b. Normal variations in concentration and how maintained 7. Blood lipins a. In general — their sources b. Cholesterol	
C. The oxygen — carbon dioxide exchange 1. The vital need for oxygen 2. Transportation to the cells	Throughout the study covered under C through F, the class should draw heavily upon knowledge of the principles of chemical equilibrium and the adjustments of weak electrolytic systems

OUTLINE OF CONTENT

3. Hemoglobin
   - a. Within red blood cells
   - b. Composition
   - c. Synthesis and destruction
   - d. As a carrier for oxygen
   - e. As a carrier for carbon dioxide
   - f. Other combinations — their importance
     - (1) Carbon monoxide
     - (2) Methemoglobin
4. At the cells*
   - a. Conditions favoring discharge of oxygen to cells
   - b. Provision for transportation of carbon dioxide
5. At the lungs*
   - a. Conditions favoring discharge of carbon dioxide
   - b. Carbonic anhydrase
   - c. The chloride shift
   - d. Conditions favoring making of oxyhemoglobin
6. Chemical control of respiratory center

D: Adjustments of hydrogen-ion concentrations, of blood, lymph, and cells

1. The relative constancy
   - a. Normal fluctuations in health
   - b. The extremes reported for the living animal
2. Normal conditions functioning to increase
   - a. Hydrogen-ion concentration
   - b. Hydroxyl-ion concentration
3. The regulating mechanism
   - a. Buffer systems
   - b. Escape of carbon dioxide

SUGGESTED DEVELOPMENT

* Simple charts are quite invaluable as visual aids for following these related processes.

OUTLINE OF CONTENT

- c. Selective elimination of salts by kidneys
- 4. A buffered solution*
  - a. Meaning of buffer solution
  - b. Essential components for a buffer system
  - c. Adjustment to entrance of
    - (1) An acid
    - (2) A base
  - d. Some buffered solutions of biological interest
- 5. Buffer systems of blood, lymph, and cells
  - a. In plasma and lymph
  - b. In cells
  - c. Reactions involved in the functioning of each system
  - d. Effect of carbon dioxide elimination
  - e. Comparative efficiencies
  - f. Exchange between cells and plasma
- 6. Acidosis and alkalosis**
  - a. Meaning of each term
  - b. Common causes — metabolic and respiratory
  - c. Alkali reserve — meaning

E. **Functioning of the kidneys**

- 1. Regulation of hydrogen-ion concentration
  - a. The hydrogen-phosphate-ion ratio
  - b. Ammonium metabolism—with conservation of sodium ions
  - c. *p*H of urine — normal variations
- 2. Other substances eliminated in urine

F. **Various local disturbances** and adjustments to maintain the environment for the living cells**

SUGGESTED DEVELOPMENT

* Demonstration of the functioning of a buffered solution provides an effective opening for class discussion.

Laboratory

A study of the functioning of a buffer system; a study of the components of blood. The extent of this study can be varied according to time available.

** In the discussion of adjustments made within the body to various types of local disturbances, that which is most important is that students think through the possibilities for themselves. The information which is available in textbooks can then be used for verification.

SUGGESTIONS FOR STUDY AND DISCUSSION

1. What is the meaning of the term "homeostasis" as it is used by Cannon in *The Wisdom of the Body?*
2. a. To what components of blood is antibody action attributed?
   b. What experimental evidence, relating to the synthesis and destruction of blood proteins, appears to account for the relatively short duration of passive immunity as compared with active immunity? (See John R. Marrack, "Immunity," *Annual Review of Biochemistry*, Vol. 11, 1942, pp. 629, 638; also H. Borsook and J. W. Dubnoff, "The Metabolism of Proteins and Amino Acids," *ibid.*, Vol. 12, 1943, p. 186.)
3. a. What is the meaning of the term "hypoproteinemia"?
   b. Mention three conditions which can result in depletion of blood proteins. From what sources are these proteins regenerated?
   c. What implications for diets does this suggest?
4. a. Which of the components of blood function to maintain osmotic pressure?
   b. How is the collection of fluid in the tissues, sometimes associated with malnutrition, accounted for?
5. a. How does clotting of blood safeguard the living cells?
   b. What prevents clotting under normal conditions?
   c. Follow the sequence of reactions which (according to one of the generally accepted theories) occur when the blood clots following a tissue injury.
   d. What is the relation of vitamin K to the clotting mechanism? Why is the provision of this vitamin of special importance for the newborn baby?
6. What use is made of fibrin film and fibrin foam? What is their source?
7. Why is sodium citrate sometimes added to blood? Explain. Assemble the equation for the resulting reaction.
8. Of what is nonprotein nitrogen composed? What are the sources of the various components?
9. a. What is blood sugar? Its source? Its function?
   b. What is its normal concentration in the blood?
   How is this controlled? How does it vary, normally, with meals?
   c. What deviation from normal occurs in the diabetic?
   d. Is glucose eliminated by the kidneys under normal conditions? Explain.
10. By what two means is oxygen carried to the cell? Can the quantity carried to the cells be increased by increasing the concentration of oxygen in the inhaled air — as in an oxygen tent where the concentration is about 50 per cent? Explain.

11. Why should lack of energy be expected to accompany anemia due to hemorrhage?

12. a. How does the administration of oxygen function in carbon monoxide poisoning?
    b. What similarities and what differences exist between carbon monoxide poisoning and poisoning due to formation of methemoglobin?

13. Trace the oxygen-carbon dioxide exchange from the lungs to the actively functioning cells, and back to the lungs indicating:

    a. Conditions at the lungs which favor entrance of oxygen to the blood stream and the formation of oxyhemoglobin.
    b. Conditions at the cells which favor decomposition of oxyhemoglobin, oxygen-carbon dioxide exchange, and transportation of carbon dioxide.
    c. Formation of carbon dioxide and its escape at the lungs.

    Assemble equations for reactions which occur at each stage of the process.

14. a. What is a buffer solution? What are the essential components of a buffer system? Illustrate by reference to a buffer system encountered in the saliva.
    b. How would this typical buffer solution respond to (1) the entrance of an acid beverage? (2) the entrance of an alkaline mouthwash?

15. a. When the reaction of blood is a *p*H of 7.4, which is present in higher concentration, hydrogen ions or hydroxyl ions? What is the exact concentration of each, in moles per liter?
    b. What are the concentration relationships between these ions in extreme acidosis, as represented by a *p*H of 7?

16. a. Is an alkaline reaction for urine abnormal? Explain.
    b. What two mechanisms function at the kidneys to conserve the buffer salts in the blood? Explain how each functions.
    c. Under what conditions would this process be reversed?

17. What various adjustments can the body make, in the blood, at the lungs, and at the kidneys in an attempt to maintain the normal environment for the living cells under each of the following conditions (**See note page 202.)

    a. Entrance of lactic acid during vigorous exercise.
    b. Absorption of a large quantity of sodium bicarbonate.
    c. Obstruction to the escape of carbon dioxide at the lungs.
    d. Loss of hydrogen ions and chloride ions owing to persistent vomiting.
    e. Accumulation of sulfates in the blood because of failure of kidneys to excrete salts in normal quantities.

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Unit X

OTHER IMPORTANT FUNCTIONINGS OF SALTS — 2 HOURS

Major objectives of the unit. To become familiar with the part that salts play in maintaining a healthy body, and to develop an understanding of the adjustments which the body makes to deficiencies and other disturbances related to their metabolism. To provide some practice in gathering and interpreting scientific information such as that which the nurse should have at her command when teaching others regarding nutrition and health.

Overview. The functioning of salts and their ions has tended to be neglected in the chemistry courses in schools of nursing. But when the frequency and importance of disturbances associated with deficiencies in calcium, phosphorus, iron, and iodine metabolism are recognized, it should be apparent that nurses need to know how the body reacts and attempts to adjust to such deficiencies. This study should, therefore, provide needed information from which the nurse will draw in her capacity of teacher when dealing with problems of nutrition and health. This information should also contribute to a better understanding of various pathological conditions associated with disturbances of mineral metabolism.

Before undertaking the study of the chemistry of bones and teeth, the students should review the principles of chemical equilibrium — especially in relation to concentrations of ions in saturated solutions.

If the unit on vitamins (Unit VI of this course which was suggested as optional) was omitted, special attention can be given to the chemistry of vitamins A, D, and C in connection with their functioning in the metabolism of bones and teeth.

OUTLINE OF CONTENT

A. **Introduction**
   1. Sources of salts and their ions
   2. Absorption from intestine
      - a. Dependent upon solubility
         - (1) Some interfering reactions
         - (2) In relation to *p*H
      - b. Other conditioning factors

B. **Important functions of salts and their ions**
   1. Control of neuromuscular irritability — by sodium, potassium, calcium, and magnesium ions
      - a. Interrelated functioning
      - b. Antagonistic ions
   2. Control of osmotic pressure by sodium and potassium chloride
      - a. Distribution of ions between cells and plasma
      - b. Excretion
         - (1) Regulation by kidneys
         - (2) By the skin
         - (3) The problem of excessive perspiration
   3. Contribute to structure of bones and teeth
      - a. Composition of bones and teeth
      - b. Factors affecting absorption
         - (1) Of calcium ions
         - (2) Of phosphate ions
      - c. Calcium and phosphate in blood and lymph
         - (1) As ions — concentration
         - (2) In organic compounds

SUGGESTED DEVELOPMENT

Lecture and discussion

Preliminary to this study the class might be asked to review the study of physiological chemistry to date and compile a list showing the functioning of metal and acid-radicals ions encountered thus far. Such information can then be organized, along with the new, in the study of this unit.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
d. Factors affecting calcification (1) Calcium and phosphate ions* (a) Solubility product (b) Ratio (2) Phosphatase — its function (3) Hormone control (4) Vitamins	* Review solubility product and demonstrate the effect of changing the concentration of either contributing ion in a saturated solution.
e. Exchange between plasma and bone (1) An equilibrium situation (2) Influence of diet (3) Acidosis — the demand for phosphate ions	
f. Exchange between plasma and teeth (1) Evidence of exchange (2) Rate of exchange (3) Nutritional significance	In studying the chemistry of teeth, it is important for the student to discriminate carefully between commonly held ideas and knowledge which has a scientific basis.
g. Other factors affecting tooth structure (1) Vitamins A, D, and C — functioning of each (2) Fluorides (3) Local factors in relation to caries (a) Carbohydrates and bacterial action (b) Reaction of saliva	Reports on experimental studies with relation to fluorides and the teeth will be found in current scientific literature.
h. Nutritional standards for calcium and phosphorus	
4. Other important functions of calcium and phosphates reviewed	
5. The functioning of iron and copper a. Iron contributing to hemoglobin	

OUTLINE OF CONTENT *SUGGESTED DEVELOPMENT*

        - (1) In blood and muscle cells
        - (2) Relation to anemia
    - b. Iron contributing to enzymes
    - c. The functioning of copper
    - d. Nutritional requirements
- 6. Iodine essential for functioning of thyroid gland
    - a. History
    - b. Thyroxine
        - (1) Chemical composition
        - (2) Synthesis in the body
        - (3) Relation to thyroglobulin
        - (4) Physiological functioning
        - (5) Thiourea and thiouracil — effect on thyroxine activity
    - c. Nutritional requirement
- 7. Zinc as an essential element
    - a. Contributing to insulin
    - b. Contributing to carbonic anhydrase

SUGGESTIONS FOR STUDY AND CLASS DISCUSSION

1. Which of the elements essential for normal nutrition are supplied through salts in the food? Of these, which can be depended upon to be provided through an ordinary mixed diet? Which require special dietary consideration?
2. What effect, if any, does each of the following have upon the absorption of calcium ions from the intestine? Explain.
    - a. The vitamin content of the diet.
    - b. The presence in the food mixture of spinach, oatmeal, or fruit juices.
    - c. The use of laxatives.
3. a. What, in general, is the distribution of calcium and phosphorus in the human body?
    - b. What essential functions do calcium ions and phosphate ions have in the blood? Why must their concentration in this location be relatively low? What other means of transportation is provided in blood?

4. How is the deposit of salts in the bones affected by each of the following:
   a. The concentrations of calcium and phosphate ions. Must these ions be present in equivalent concentrations. Explain.
   b. The enzyme phosphatase.
   c. Vitamin D.
   d. The hormone balance in the body.
5. a. What is the effect on the skeletal structure when insufficient calcium is provided in the diet? (Consult Henry C. Sherman, *Chemistry of Food and Nutrition*, 7th ed., Chap. XIV.)
   b. What response, other than in the skeleton, has been observed when the calcium level of blood is abnormally low?
6. On the basis of authoritative information gathered from textbooks and scientific literature, summarize your conclusions with regard to possible effects of each of the following to the problem of dental caries. Call attention to problems where judgment must be suspended because of inadequate evidence.
   a. Milk in the diet of (a) the growing child, (b) the adult.
   b. Vitamin content of diet.
   c. Candy and other sugars.
   d. Alkaline mouthwashes and tooth pastes.
7. What effect does the presence of fluorides in the water supply have on tooth structure? What are the findings in relation to the incidence of dental caries and fluoride content of water?
8. List the various phosphate compounds encountered in the body and, whenever possible, their functioning. Draw your own conclusion as to the importance of this element.
9. Would a deficiency of iron salts affect the welfare of the body other than in relation to the transportation of oxygen to the cells? Give reasons for your conclusion.
10. a. What is the functioning of thyroxine in relation to metabolism? How is this related to the problem of iodine deficiency?
    b. What is thiouracil? How does it influence thyroid function?

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Unit XI

RADIOACTIVE ELEMENTS — THEIR BIOLOGICAL INTEREST — (AN OPTIONAL STUDY) — 2 HOURS

Major objectives of the unit. To provide a basis for understanding radioactive elements in relation to their therapeutic use and to the hazards against which patients and all those who handle such materials should be safeguarded. To provide a basis for better understanding of references to the use of isotopic elements in biological and medical research, thus facilitating this type of professional reading.

Overview. Students who have had a college course in general chemistry are undoubtedly familiar with the concepts of atomic structure, and in most instances they will have made some study of radioactivity. This earlier study will have centered about the interest which these studies have for the scientist. The purpose of this unit is to recall this experience and to use it as the background for discussing radioactive elements as therapeutic agents and hazards encountered in their use, both in hospital and in industry.

The newly discovered unusual isotopes of common elements, both stable and radioactive, are already being used in studies of biological importance, including medical research. Some information concerning these isotopic elements, their nature and use, will be helpful to the modern nurse who would keep up with the developments in medical science and their influence on her practice as a nurse.

This unit is suggested as *optional* only because the theoretical background for understanding the application of radium therapy will have been provided in the college course and the study of applications could, reasonably, be delayed for incorporation in the curriculum when the student studies radiation therapy. Unfortunately, at this later period, the explanation afforded is often inadequate, the knowledge of chemistry being taken for granted.

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
A. **Radioactive Elements** 1. History of their discovery 2. The ejections and their characteristics 3. The natural radioactive elements 4. Spontaneous disintegration — meaning and significance	A and B. **Lecture** illustrated by charts The history of this development is so thrilling that there should be no great difficulty in providing "appetizers" which will encourage further reading from sheer interest.
B. **Theory accounting for radioactivity**	
1. *Review:* Structure of the atom a. General structural features b. The contributing particles (1) Their nature (2) Their distribution c. Atomic weight accounted for d. Atomic number — meaning and significance e. Isotopic atoms — meaning f. The structure of the nucleus (1) Of typical atoms (2) Of isotopic atoms	A rapid review of atomic structure is suggested, stressing the points which the class will need to keep in mind for the discussion to follow.
2. The nuclei of radioactive atoms a. The crowded condition b. The extent of the charge c. The consequent adjustment	
3. Following the sequence of ejections in the disintegration of radium a. Alpha and beta particles — their composition b. The gamma ray — its character c. The end products	

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
4. The speed of disintegration a. For uranium, radium, and radon b. Half-life period — meaning of term C. **Radioactive elements and their physiological effects** 1. The ejections and their effects on tissue cells a. The gamma ray (1) Penetration (2) Compared to X ray b. The alpha particles c. The beta particles 2. Therapeutic use of radium salts and radon a. The principle involved b. Necessary safeguards in handling c. Their half-life periods in relation to use	C. **Discussion** under guidance of the teacher When the destructive effect of the radiations is understood by the students, with a few suggestions by the teacher, the class should be able to draw its own conclusions with regard to dangers and precautions involved in the use of radium.
d. The hospital supply of radium (1) Value (2) Permanence with relation to use 3. Radium poisoning a. As an industrial hazard b. Absorption, distribution, and excretion of radium salts c. The destructive agents d. The period of effective activity e. Some pathological effects	Where radium therapy is in practice in the institution, an opportunity for observation could be afforded in connection with the study of this unit.
D. **Radioactive isotopes of common elements** 1. History of their production 2. Typical reactions and some elements thus produced 3. The ejections compared with those of radium	D. and E. **Lecture**

OUTLINE OF CONTENT	*SUGGESTED DEVELOPMENT*
E. **Biological use of isotopic elements as tracers** 1. Stable isotopes — and some of the studies in which they are used 2. Radioactive isotopes (radio elements) — and some of the studies in which they are used.	Selected references to studies of current interest, found in medical and scientific literature, might be brought to the attention of the class.

SUGGESTIONS FOR STUDY AND DISCUSSION

1. How does spontaneous disintegration of radioactive elements differ from ordinary decomposition?
2. a. What is meant by the statement that radium has a half-life period of 1590 years? What does this mean in terms of the permanency of the radium supply of an institution?
   b. Will the quantity or efficiency of radium be conserved by keeping it out of active use? Explain. What does this suggest with regard to the freedom with which this element should be made available for use when needed?
3. a. Describe the three varieties of ejections associated with radium element:
   b. Which of these ejections functions in radiotherapy? What becomes of the others?
   c. Why is it possible to use radium for the destruction of cancer cells without also destroying other tissues with which it must come in contact? Do the exposed healthy tissues escape injury? Explain.
4. With relation to radium used in the hospital:
   a. What is the provision for storage?
   b. What protection is afforded those who handle it?
   c. How do these practices relate to the properties which characterize the ejections?
5. In the event of accidental loss of even a small amount of radium, it is imperative that it be located, if at all possible. For what two important reasons?
6. Radon is sometimes left in contact with tissue for an indefinite period of time, whereas radium is always removed promptly at the end of a definitely specified time.
   a. Account for this difference in practice.
   b. Compare the dosage of gamma rays which the patient would be receiving from radon at the end of a week with that received at the time of its insertion.
   c. Does a similar situation exist for radium? Explain.

7. a. To what types of radiation is the unprotected radium worker exposed (1) while handling radioactive material, (2) when radium salts have been accidentally ingested?
   b. Where do radium salts find their location in the body? In this connection, note to which element group radium belongs.
   c. In what two ways are the effects of ingested radium diminished in the course of time? Will this radioactivity ever cease? Explain. How long is it estimated to require before its activity within the body will diminish by half?
8. Compare artificially produced radioactive elements with those of natural occurrence as to (a) nature of the ejected particles, (b) half-life periods. What does this suggest as to their relative effects on exposed tissues?
9. a. Mention some studies of biological interest which are being carried on with radioactive isotopic elements. What is one method by which the distribution of radioactive material in a tissue specimen can be detected?
   b. Mention some important studies which have been made with the stable isotopic elements.

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APPENDIX

COMPARISON OF TEXTBOOK CONTENT

The content of 10 textbooks for use in introductory courses in college chemistry is shown in comparison with the content suggested for inclusion in a chemistry course in a school of nursing. The latter is represented by the outline in *A Curriculum Guide for Schools of Nursing.*

Key: CG — Used to indicate the *Curriculum Guide*
Numbers 1 to 10 — used to indicate the 10 textbooks in college chemistry.
X — items in the *Curriculum Guide* outline
x — items in the college textbooks which receive reasonable and consistent treatment from text to text
z — items included, but in some other section of text
* — items which show limited or incidental treatment in the textbook specified
m — items which receive mention only
v — items covered by statements which are vague, inaccurate, or very general

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
GENERAL CHEMISTRY											
Some fundamental concepts											
1. Substance											
a. Defined or term explained	X		x	x	x		x	x	x		x
b. Specific properties	X	x	x	x	x	x	x	x	x	x	x
Density, boiling point, freezing point	X	z	z	z	z	z	z	z	z	z	z
2. Mixtures											
a. Characteristics of mixtures	X	x	x	x	x		x	x	x	x	x
b. Solutions as mixtures		x	x	x		x		x			x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
3. Physical and chemical change											
a. Nature of physical change	X	x	x	x	x		x	x	x	x	x
b. Nature of chemical change	X	x	x	x	x	x	x	x	x	x	x
c. Experimental evidence	X	x	x	x	x	x		x		x	
d. Law of chemical change	X							x			
e. Types of chemical change	X	x	x	x	x		x	x	x	x	x
f. Law of conservation of mass	X	x	x	x	x	x	x	x	x	x	x
g. Word equation	X										
h. Factors affecting speed	X			x	x	x	x	x	x	*	x
4. Element versus compound											
a. Two uses for term element	X										
b. Elements — building materials for substances	X	x	x	x	x	x	x	x	x	x	x
How many known	X		x	x		x	x	x	x	x	x
Contribute to earth's crust	X	x	x	x	x	x	x	x	x	x	x
Contribute to human body	X	x			x		x	x	x	x	
Metal versus nonmetal				x	x	x	x	x		x	x
c. Compounds											
Distinguished from elements	X	x	x	x	x	x	x	x	x	x	x
Defined, experimental basis	X					x	x	x	x	x	
Law of definite proportions	X	x	x	x	x	x	x	x	x	x	x
Law of multiple proportions		x	x	x		x	x	x	x	x	
Naming, prefixes and endings	X		x	x		x			x	x	
Stability of compounds	X							x			
d. Chemical activity, defined	X							x			
5. Catalysts											
a. Defined	X		x	x	x	x	x	x	x	x	x
b. Illustrated											
Laboratory experiences	X	x	x	x	x	x	x	x	x	x	x
Everyday contacts	X							*			
Industrial uses	X	x	x	x	x	x	x	x	x	x	x
Enzymes as catalysts	X					x					x
c. Theoretical explanation		x	x	x			x				
Oxygen, combustion, energy											
1. Oxygen — the element	X										
a. Occurrence	X	x	x	x	x	*	x	x	x	x	

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
2. Oxygen — the substance	X										
a. History of discovery	X	x	x	x	x		x	x	x	x	*
b. Preparation											
Laboratory	X	x	x	x	x		x	x	x	x	x
Commercial	X	x	x	x	x	x	x	x	x	x	x
c. Physical properties											
Listed	X	x	x	x	x		x	x	x	x	x
Importance to man	X										
d. Chemical reactions with:											
Metal substances	X	x	x	x			x	x	x	x	x
Nonmetal substances	X	x	x	x			x	x	x	x	x
Compounds	X	x	x	x				x	x	x	
e. Functioning (or uses)											
Physiological importance	X	m	m	v	v		v	v	m	v	v
In decay	X							x			
In production of heat and kinetic energy	X	x	x	x	x		x	x	x		x
f. Commercial supplies of oxygen											
Therapeutic uses	X			x	x		x		x	x	x
Uses in exploration, etc.	X	x		x			x	x	x		
In torches, with hydrogen or acetylene	X	x	x	x	x		x	x	x	x	x
3. Oxides — metal and nonmetal			x				x	x	x	x	x
4. Oxidation, slow and rapid		x		x	x		x	x	x	x	x
5. Combustion or burning											
a. Definition	X	x		x	x		x	x	x	x	
b. Essential conditions	X			x	x		x		x	x	
c. Fire control and prevention	X				x						
d. Spontaneous combustion		x	x	x	x	x	x	x	x	x	x
6. Ozone											
a. Occurrence			x		x		x	x	x	x	
b. Preparation		x	x	x	x	x	x	x	x	x	x
c. Properties — oxidizing agent		x		x	x		x	x		x	x
d. Uses		x	x	x	x		x	x	x	x	
7. Energy transformations during chemical changes											
a. Energy versus matter	X	x	x	x	x		x				
b. Varieties of energy	X	x	x	x	x		x	x	x		

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
c. Transformations of energy	X	x	x				x	x	x	x	
d. Measurement of energy	X	x		x	*	x	x		x	x	
The basis of measurement	X	x	x	x		x	x		x	x	
Calorie, small, defined		x	x	x		x	x		x	x	
Calorie, large, defined	X	x				x	x		x	x	
The calorimeter		x		x		x	x	*	x	x	
e. Law of conservation of energy	X	x	x	x	x	x	x	x	x	x	
f. Associated with chemical reactions	X	x	x	x			x	x		x	x
Endothermic reactions	X	x		x		x	x		x	x	x
Exothermic reactions	X	x		x		x	x		x	x	x
Equation representation, with interpretation	X										
Thermochemical equations		x		x		x	x	x		x	
The desired products: may be energy, may be matter	X										
g. Biological importance											
In photosynthesis	X										
In metabolic reactions	X										
h. Explosions, conditions for					x	x		*	x	x	
Physical states of matter											
1. Gaseous substances											
a. Properties of gases	X	x	x	x	x	x	x	x		x	x
b. Boyle's law	X	x	x	x	x	x	x	x	x	x	x
c. Charles's law	X	x	x	x	x	x	x	x	x	x	x
d. Dalton's law, partial pressure		x	x	x	x	x	x	x	x	x	x
e. Graham's law, gas diffusion		x	x	x	x	x	x	x	x	x	x
f. The ideal gas		x	x		x		x	x			x
g. Deviations from gas laws		x	x	x				x		x	x
h. Density, defined	z		x	x		x		x	x		
i. Molecular — kinetic theory	X	x	x	x	x	x	x	x	x	x	x
Assumptions	X	x	x	x	x	x	x	x	x	x	x
To account for properties of gases	X	x	x	x	x	x	x	x	x	x	x
Gases contrasted with liquids and solids	X			x			x	x	x		
j. Critical temperature		x	x	x	x		x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
k. Critical pressure		x	x	x			x		x	x	x
2. Liquids											
a. Properties of liquids	X		x	x	x		x	x	x	x	x
b. Boiling point	z	x	x	x	x		x	x	x	x	x
c. Heat of vaporization		x	x	x			x	x	x	x	x
d. Vapor pressure		x	x	x	x	x	x	x	x	x	x
e. Distillation		x	x	x	x	x	x	x	x	x	x
3. Solids											
a. Properties of solids	X		x	x	x		x	x			x
b. Freezing (or melting) point	z	x	x	x	x		x	x	x	x	x
c. Heat of fusion			x	x			x	x	x		x
d. Crystalline structure		x	x	x	x	x	x	x	x	x	x
Chemical measurings — laws and theories — chemical shorthand — atomic structure											
1. Atomic weights and atoms											
a. Atomic weights of elements	X	x	x	x	x	x	x	x	x	x	x
Defined	X	x	x	x	x	x	x	x	x	x	x
As unit combining weights	X	x		x					x		
Methods for determining		x	x	x	x	x	x	x	x	x	x
b. Atomic theory	X	x	x	x	x	x	x	x	x	x	x
History			x	x	x		x	x			x
Dalton's assumptions	X	x	x	x	x	x	x	x	x	x	x
To account for facts	X										
Law of definite proportions		x	x	x	x	x	x	x	x		x
Law of multiple proportions		x	x	x	x		x	x	x		x
Law of conservation of mass		x	x	x	x	x	x				
2. Molecular weights and molecules											
a. Molecular weights of substances	X	x	x	x	x	x	x	x	x	x	x
Defined		x	x	x	x	x		x		x	x
Mole — gram molecular weight		x	x	x	x	x	x	x	x	x	x
Molar volume		x	x	x	x	x	x	x	x	x	
Unit reacting weights	X										
Experimentally determined	X										
Methods for determining		x	x	x	x	x	x	x	x	x	x
Molecular weight problems		x	x	x		x	x	x	x	x	

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. Molecular theory	X	x	x	x	x	x	x	x	x	x	x
Molecule defined	X	x	*	x	*	x	x	x	x	*	
3. Relationships											
a. Molecular weight and atomic weight	X		x		x		x				
b. Molecule and atom	X			x	x		x	x			x
c. Mass reaction and molecule involvement	X										
4. Avogadro's hypothesis		x	x	x	x	x	x	x	x	x	x
5. Gay-Lussac's law		x	x	x	x	x	x	x	x	x	x
6. Chemical shorthand											
a. History of its development	X	x					x	x			
b. The symbol — its function	X	x	x	x	*	*	x	x	*	x	x
c. The formula											
Its function	X	x	x	x	*	x	x	x	*	x	x
Experimental basis	X	x		x	x		x	x	x	x	
Method for determining		x	*	x	x	x	x	x	x	x	x
Interpretation of a formula	X	x	x	x	x	x	x	*	x	x	x
d. The formula equation											
Information necessary	X	x		x	x	x	x	x	x		x
Method for assembling	X	x	*	x	x	x	x	x	x	x	x
Quantitative interpretation	X	x	x	x	x	x	x		x	x	x
Fulfills the law of conservation of mass	X						x				
e. Formulas and equations used in problem solving		x	x	x	*	x	x	x	x	x	x
f. Radical parts of compounds	X	m	x	x	x	m	x	x	x	x	m
Meaning of term radical	X		x	x	x		x	x	x	x	
Compounds composed of radical parts	X										
Charge carried by radicals	X			x	x			x			
g. Valence											
Defined	X	x	x	x	x	*	x	x	x	x	x
Experimentally determined	X	x		x			x	x		x	x
Positive and negative	X	x	x	x	x	x	x	x	x	x	x
Covalence and co-ordinate valence		x	x	x	x	x	x	x	x	x	x
h. Assembling formulas — method	X	x	x				x	x		x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
i. Structural formulas	X	x	x	x	x	x	x	x	x	x	x
7. Atomic structure — modern atomic theory											
a. Historical concepts of constitution of matter			x	x	x		x	x	x	x	
b. Particles contributing to atoms	X	x	x	x	x	x	x	x	x	x	x
c. Nucleus of the atom											
Particles within nucleus	X	x	x	x	x	x	x	x	x	x	x
Mass of atom		x	x	x	x	x	x	x	x	x	x
Atomic number — meaning		x	x	x	x	x	x	x	x	x	x
Isotopes		x	x	x	x	x	x	x	x	x	x
d. Radioactivity											
History of discovery		x	x	x	x		x	x	x	x	x
Nature of ejections	X	x	x	x	x	x	x	x	x	x	x
Disintegration of uranium		x	x	x			x	x		x	x
Disintegration of radium	X	x	x	x	x		x	x	x	x	x
Gamma rays and X rays	X						x	x	x		
Therapeutic action	X						x		x		
Radium in industry		x			x		x	x	x		
Artificial radioactivity		x	x	x	x	x	x	x	x	x	x
Unusual isotopes used in research			x		x	x	x	x			
e. Field external to nucleus of atom — Bohr theory											
Electron configuration	X	x	x	x	x	x	x	x	x	x	x
Relation to valence	X	x	x	x	x	x	x	x	x	x	x
8. Periodic table of elements											
a. Historical		x	x	x	x	x	x	x	x	x	x
b. On basis of atomic weights		x	x	x	x	x	x	x	x	x	x
c. On basis of atomic number		x	x	x	x	x	x	x	x	x	x
d. Chemical relationships											
Metals and nonmetals			x	x	x		x	x			x
Family groups of elements			x	x	x				x	x	x
Valence relationships			x	x	x		x	x		x	
Water and hydrogen peroxide											
1. Water											
a. Occurrence in nature	X	x	x	x	x		x	x	x	x	
b. Composition	X	x	x		x			x	x	x	

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
c. Physical properties — their importance	X										
Density			x	x		x	x	x	x	x	
Boiling point		x		x		x	x	x	x	x	z
Freezing point		x		x		x	x	x	x	x	z
Specific heat		x	x	x		x	x	x	x	x	
Heat of vaporization		x	x	x		x	x	x	x	x	z
Heat of fusion		x	x	x		x	x	x	x	x	z
Vapor pressure		x		x		x		x	x	x	
As a solvent		x			x		x	x	x	x	
d. Natural water supplies											
Composition		x	x	x	x		x	x	x	x	
Purification	[1]	x	x	x	x	x	x	x	x	x	z
Hard water (also see salts)	z	x	x	x	x		*	x	x	x	z
e. Chemical behavior											
Stability			x	x	x		x	x	x		
Water with metals	X		x	x	x		x	x	x	x	z
Water with oxides	X	x	x	x		x	x	x		x	
Water with chlorine	z		x	z			x	x		x	z
f. Hydrates											
Composition of hydrates	X	x	x	x	x		x	x	x	x	z
Efflorescence		x	x	x	x		x	x	x	x	
g. Hydrolysis											
Defined	X	z	z	x	z	z	z	x	z	z	z
Of salts	X	z	z	x	z	z	z	x	z	z	z
Reaction of salt solutions	X	z	z	x	z	z	z	x	z	z	z
Biological importance	X										
2. Hydrogen peroxide											
a. Preparation		x		x		x	x	x	x	x	x
b. Properties		x	x	x		x	x	x	x	x	
c. In oxidation and reduction		x	x	x		x	x	x	x	x	x
d. Uses		x	x	x		x	x		x	x	x
Solutions — true and colloidal											
1. True solution											
a. Solution defined or described	X	x	x	x	x	x	x	x	x	x	x
b. Solvent and solute		x	x	x			x	x	x	x	x
c. Various types of solution	X	x		x	x	x			x	x	x

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[1] Included in microbiology course.

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
d. With a liquid solvent											
Concentrated versus dilute	X	x					x	x		x	x
Unsaturated versus saturated		x	x	x	x		x	x	x	x	x
Supersaturated solution		x	x	x	x		x	x	x	x	x
Crystallization		x		x			x	x	x	x	
e. Methods for expressing concentration											
Ratio or per cent	X										x
Molar concentration	X	x	x	x		x	x	x	x	x	x
Normal concentration	X	x	x	x	x	x	x	x	x	x	x
f. Solubility of gases											
Henry's law		x	x	x	*	x	x	x	x	x	x
Law of partial pressures		x	x	x				x		x	
g. Factors affecting speed of solution	X	x	x	x		x	x	x	x	x	x
h. Vapor tension		x	x	x	x		x	x	x	x	x
Raoult's law		x	x	x			x	x	x		
Deliquescence		x	x	x	x		x	x	x		
i. Boiling points and freezing of solutions compared with those of pure solvent	X	x	x	x	x		x	x	x	x	x
j. Fractional distillation		x	x	x			x			x	
k. Osmotic pressure and diffusion through membrane	X	x	x	x	x		x	x	x	x	x
l. True solution contrasted with:											
Colloidal solution	X	x		x			x			x	x
Suspension		x		x			x			x	x
2. Colloidal solution											
a. Types of dispersion		x		x	x					x	x
b. Size of particle		x	x	x	x		x	x	x	x	x
c. Tyndall effect		x	x	x	x			x	x	x	x
d. Brownian movement		x	x	x	x	x	x	x		x	x
e. Charges carried by particles		x	x	x	x	x	x	x	x	x	x
f. Methods of preparation		x	x	x	x	x	x	x	x	x	x
g. Dialysis											
In relation to separation from crystalloids		x		x	x	*	x	*	x	*	x
In relation to biology	X										

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
3. Emulsion											
a. Defined	X	x	x	x		x	x	x	x	x	
b. Emulsifying agents	X	x	x	x	x	x	x	x	x	x	x
c. Surface tension and emulsion	X			x		x	x	x			x
4. Adsorption	X	x	x	x	x	x	x	x	x	x	x
a. Defined	X		x	x	x		x		x		x
b. Relation to surface forces	X		x	x	x		x	x	x	x	x
c. In practical situations	X	x	x	x	x	x	x	x	x	x	x
5. Gels and jellies			x	x	x		x	x	x	x	x
6. Protective colloids			x	x	x	x	x		x		x
Acids, bases, and salts											
1. Contributing radicals (or ions)											
a. Of acids	X	x				x					
b. Of bases (metal hydroxides)	X	x				x					
c. Of salts	X		x	x		x					
2. Reaction expectations from contacts of:											
a. Acids with metals	X		x		x	x		x			
b. Acids with metal oxides	X					x					
c. Bases with metals	X										
d. Salts with metals	X		x		x						
e. Acid with base	X			x	x	x	x	x	x		
f. Acids with salts	X		z		x		x	x			
g. Bases with salts	X		z		x		x				
h. Salts with salts	X		z			x	x				
i. Practical results of such contacts in daily life	X										
3. Naming of acids, bases, salts	X			x	x	x					
4. Salts											
a. Normal salts	X	x	x			x	x	x			x
b. Acid salts	X	x	x	x		x	x	x	x		x
c. Basic salts			x	x		x	x	x			x
d. Double or mixed salts			x			x	x				x
5. Salts and hard water											
a. Responsible for hardness	X	z	z	z	z	x	z	z	x		z
b. Softening of hard water	X	z	z	z	z	x	z	z	x		z

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Ionization											
1. Electrolytes and nonelectrolytes	X	x	x	x		x		x	x		x
a. Electrical conductivity of solutions	X	x	x	x			x	x		x	
b. Chemical activity					x	x	x				x
c. Abnormal freezing points and boiling points of solutions of electrolytes		x	x	x	x	x	x	x	x	x	x
d. Weak and strong electrolytes	X		x	x	x	x		x	x	x	x
2. Theory of Arrhenius											
a. Assumptions	X	x	x	x		x		x	x	x	x
b. Ionization and conductivity	X	x	x	x	x	x	x	x	x	x	x
c. Electrolysis explained			x	x		x	x	x	x	x	x
d. Faraday's law			x	x			x	x		x	x
e. Objections to this theory		x	x	x				x			x
3. Debye-Hückel theory											
a. Ionization of strong bases and salts		x	x	x	x	x	x	x	x	x	
b. Interionic interference		x	x	x	x	x		x	x	x	
4. Ions and crystal structure		x	x	x	x		x	x	x	x	
5. Ionization of acids		x	x	x		x		x		x	
6. The nature of ions	X	x		x		x			x	x	x
7. Acids											
a. Sources of hydrogen ions	X	x	x	x			x	x	x		x
b. Sources of hydronium ions				x	x				x		x
c. Accounting for characteristics common to all acids	X		x		x			x	x		x
8. Bases											
a. Sources of hydroxyl ions	X	x	x		x		x	x	x		x
b. Accounting for properties common to bases (hydroxides)	X		x	x	x		x	x	x		x
c. Alkalies in relation to bases	X										
9. How secure desired concentrations											
a. Of hydrogen ions in solution	X										
b. Of hydroxyl ions in solutions	X										
c. Safe concentrations for practical daily uses, etc.	X										

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
10. Salts											
a. As strong electrolytes	X	x			x	x	x	x	x		x
b. As weak electrolytes (pseudo-salts)	X	x				x	x				x
11. Ions of physiological importance	X										
12. Ionic reactions											
a. Equation representations		x	x	x			x	x	x	x	x
b. Effect of formation of a precipitate		x		x			x	x			x
c. Effect of escape of insoluble gas		x		x			x	x			
d. Effect of weak electrolyte product		x		x				x			
e. Hydrolysis	z			x		x	x	x			x
f. Neutralization	X	x	x	x	x	x	x	x	x	x	x
13. Brönsted concept of acid and base				x	x	x		x	x	x	
a. Acids as proton donors		x		x	x	x		x		x	
b. Bases as proton acceptors		x		x	x	x		x		x	
Chemical equilibrium											
1. Reversible reactions	X	x	x	x	x	x	x	x	x	x	x
2. Concerning equilibrium											
a. Essential conditions	X	x				x		x	x		x
b. Equilibrium constants		x	x		x	x	x	x		x	
c. Law of mass action		x	x	x	x	x	x	x	x	x	x
d. Effect of change											
Of temperature		x	x	x	x	x	x	x	x	x	x
Of pressure (Le Châtelier's law)		x	x	x		x	x	x	x	x	x
e. Catalysis in relation to		x	x	x		x	x	x		x	x
3. Equilibrium in electrolyte systems											
a. Ionization constants		x	x	x	x	x	x	x		x	x
b. Effect of dilution			x	x						x	x
c. Effect of common ion		x	x	x						x	x
d. Activity coefficients		x	x	x	x	x					
e. Solubility product		x	x	x	x	x	x	x		x	
4. Equilibrium within a water system											
a. Ionization of water	X	x	x	x	x	x	x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. Ionization constant for water		x	x	x	x	x		x	x	x	x
c. The ion relationship	X	x	x	x	*		x	x	*	*	
d. Measurement of hydrogen-ion (hydroxyl-ion) concentration											
Basis for measurement	X	x									
Electropotential method		x		x							
Colorimetric method	X	x				*					
Color indicators	X	x	x	x	x	x	x	x	x		
e. The *p*H notation	X	x	x	x	x	*	x	x	x	x	
f. Importance of *p*H in relation to											
Bacterial growth	X										
Sterilization	X				x						
Cookery and canning	X			x							
Physiology	X			x							
Industrial processes	X	z	x		x		*				
5. Buffered solutions											
a. Functioning of	X	*	x		x		*	*			
b. Physiological importance	X				x						
Acidometry and alkaliometry											
1. Standard solutions		x	x	x	x	x	x	x	x	x	x
2. Titration		x	x	x	x	x	x	x	x	x	x
Oxidation-reduction											
1. Complementary processes	X		x								
2. Older viewpoint (oxygen involved)	X	x		x	x		x	x	x	x	*
a. Oxidation defined	X	x		x	x			x			*
b. Reduction defined	X	x		x	x			x			*
c. Oxidizing and reducing agents	X			x							
d. In bleaching reactions	X	z	z		z	z	z	z	z	z	z
e. In disinfection	X							z			
f. Of physiological importance	X										
3. Modern viewpoint (electronic)											
a. Oxidation-reduction defined	X	x		x	x	x	x	x	x	x	
b. Oxidizing and reducing agents		x	x	x	x	x				x	x
c. Equation assembling		x	x	x	x	x	x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Electromotive chemistry											
1. Units for measuring energy		x	x	x			x	x	x	x	x
2. Reactions furnishing energy		x		x				x		x	
3. General principles		x	x	x			x	x	x	x	x
4. Electrode potentials		x	x	x			x	x	x	x	x
5. Electromotive series		x	x	x			x	x	x	x	x
6. Types of cells		x	x	x				x		x	x
7. Couples		x	x	x				x		x	x
STUDY OF ELEMENTS, NON-METAL AND METAL											
Hydrogen											
1. History and occurrence		x	x	x			x	x	x		
2. Hydrogen substance											
a. Preparation	z	x	x	x	x	x	x	x	x	x	x
Electrolysis	z	x	x	x	x	x	x	x	x	x	x
Metals with water	z	*		x		x	x	x	x	x	x
Metals with acids	z	x	x	x	x		x	x	x	x	x
Certain bases with certain metals	z	x		x			x	x		x	x
Commercial methods		x	x	x	x	x	x	x	x	x	x
b. Physical properties	*	x	x	x	x	x	x	x	x	x	x
c. Chemical properties	*	x	x	x	x	x	x	x	x	x	x
d. Industrial uses	*		x	x	x	x	x	x	x	x	x
3. Isotopes		x	x	x		x	x	x			x
The halogens											
1. History				x		x	x	x	x	x	x
2. Relationships and valence		x	x	x	x	x	x	x	x	x	x
3. For each element											
a. Occurrence		x	x	x	x		x	x	x	x	x
b. Preparation of simple substance		x	x	x	x	x	x	x	x	x	x
c. Properties of substance		x	x	x	x	x	x	x	x	x	x
d. Uses		x	x	x	x	x	x	x	x	x	x
4. Halogen compounds (also see metal salts)[2]		x	x	z	x	x	z	z	x	x	z

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[2] Salts appear in some texts under the metal elements. There is a high degree of uniformity in treatment of these halogen compounds in all texts.

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Sulfur, selenium, and tellurium											
1. Relationships and valence		x	x	x	x	x	x	x	x	x	x
2. Sulfur substance											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Commercial preparation		x	x	x	x	x	x	x	x	x	x
c. Properties		x	x	x	x	x	x	x	x	x	x
d. Industrial uses		x	x	x	x		x	x	x	x	x
3. Compounds of sulfur		x	x	x	x	x	x	x	x	x	x
4. Commercial preparation of sulfuric acid											
a. Lead-chamber method		x	x	x	x	x	x	x	x	x	x
b. Contact method		x	x	x	x	x	x	x	x	x	x
5. Selenium and tellurium — for each											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Properties		x	x	x	x	x	x	x	x	x	x
c. Uses		x	x	x	x	x	x	x	x	x	x
The atmosphere											
1. Historical		x		x					x	x	
2. Air as a mixture		x	x	x	x		x	x	x	x	x
a. Components		x		x	x		x	x	x	x	
b. Air conditioning		x		x	x		x		x	x	
c. Liquifaction of air		x		x				x		x	x
3. The inert gases											
a. Discovery		x	x	x	x	x	x	x	x	x	x
b. Uses — if any		x	x	x	x	x	x	x	x	x	x
c. Radioactivity of radon	z	x	x	x	x	x		x	x	x	x
The nitrogen group											
1. Relationship and valence		x	x	x	x	x	x	x	x	x	x
2. Nitrogen											
a. History		x		x			x	x	x	x	
b. Laboratory preparation		x	x	x			x	x	x	x	x
c. Commercial preparation		x	x	x	x	x	x	x	x	x	x
d. Properties		x	x	x	x	x	x	x	x	x	x
e. Nitrogen cycle in nature	z	x	*	x	x	x	x	x	x	x	*

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
3. Ammonia											
a. Commercial preparation											
Haber process		x	x	x	x	x	x	x	x	x	x
Cyanamide process		x	x	x	x	x	x	x		x	x
b. Laboratory preparation		x	x	x		x	x	x	x	x	x
c. Properties		x	x	x		x	x	x	x	x	x
d. Uses			x	x	x		x	x	x	x	
e. Complex ions			x	x		x	x	x	x	x	x
f. Ammonium hydroxide		x	x	x		x	x	x	x	x	x
g. Ammonium salts		*	x	x	x	x	x	x	x	x	*
4. Other nitrogen compounds											
a. Oxides		x	x	x	x	x	x	x	x	x	x
b. Acids		x	x	x	x	x	x	x	x	x	x
c. Nitrates and nitrites		x	x	x	x	x	x	x	x	x	x
d. Cyanides			x	x				x		*	
5. Phosphorus											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Phosphorus substance											
Preparation		x	x	x	x	x	x	x	x	x	x
Allotropic forms		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x		x	x	x	x	x	x
Uses		x	x	x		x	x	x	x	x	x
6. Arsenic											
a. History		x		x	x		x			x	
b. Occurrence		x	x	x	x	x	x	x	x	x	x
c. Commercial preparation		x	x	x	x		x	x	x	x	x
d. Properties		x	x	x		x	x	x	x	x	x
e. Uses of arsenic and arsenic compounds		x	x	x	x	x	x	x	x	*	x
7. Antimony											
a. Occurrence		x	x	x	x	x	x	x	x	x	
b. Commercial preparation		x	x	x		x	x	x	x	x	
c. Properties		x	x	x	x	x	x	x	x	x	
d. Antimony compounds		x	x	x		x	x	x	x	x	
e. Uses of antimony and antimony compounds		x	x	x	x		x			x	
8. Bismuth											
a. Occurrence		x		x				x		x	
b. Properties		x	x	x		x	x	x	x	x	

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
c. Compounds		x	x	x		x	x	x	x	x	x
d. Uses of bismuth compounds			x	x	x			x	x	x	x
Carbon (also see organic compounds)											
1. Occurrence		x	x	x	x	x	x	x		x	
2. Carbon simple substance											
a. Allotropic forms		x	x	x	x	x	x	x	x	x	x
b. Their properties		x	x	x	x		x	x	x	x	x
3. Carbon compounds											
a. Valence of carbon element	z		x	x	x	x	x	x	x	x	x
b. Carbon monoxide											
Preparation		x	x	x	x		x	x	x	x	x
Properties		x	x	x	*		x	x	x	x	x
Industrial uses		x	x	x	x			x		x	*
Physiological effect		x	x	x				x	x	x	x
c. Carbon dioxide											
Preparation	z	x	x	x	x	x	x	x	x	x	
Occurrence		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x	x	x	x	x	x	x	x
Uses		x	x	x		x	*	x	x	x	
Carbonic acid		x	x	x		x	x	x		x	
d. Carbonates and bicarbonates		x	x	x	x		x	x	x	*	x
e. Calcium carbide — for each		x	x	x				x	x		
Sodium carbide — preparation		x	x	x	x		x	x	x	x	x
Carbon disulfide — and uses		x	x	x			x	x		x	x
Silicon											
1. Relation to carbon		x	x	x		x	x	x	x		x
2. Occurrence		x		x	x	x	x	x	x	x	x
3. Preparation		x	x	x			x	x	x	x	
4. Properties		x		x	x	x		x		x	x
5. Silicon compounds											
a. Silicon dioxide		x	x	x		x	x	x	x	x	x
b. Silicates and their uses		x	*	x	x	x	*	x	*	x	x
c. Glass — types and uses		x	x	x	x		x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Titanium		x	x	x		x		x	x		x
Zirconium		x	x	x		x		x	x		x
Hafnium occurrence and uses		x	x	x		x		x	x		x
Thorium		x	x	x		x		x			x
Cerium				x		x		x			x
Boron											
1. Relation to carbon and silicon							x	x		x	x
2. Occurrence		x	x	x			x	x	x	x	
3. Boron substance											
a. Preparation		x	x	x		x	x	x	x		
b. Properties		x	x	x	x	x	x	x	x		
4. Boron compounds											
a. Boric acid											
Preparation		x	x	x	x		x	x	x	x	x
On heating		x	x	x		x	x	x	x		
Use as antiseptic		x	x	x	x		x	x	x	x	x
b. Borax											
Composition		x	x	x	x	x	x	x	x		x
Hydrolysis		x	x	x	x		x	x		x	x
Uses		x	x	x	x		x	x	x	x	x
Metal elements — in general											
1. Characteristic properties		x		x	x		x	x	x	x	x
2. Metallurgy — various processes		x	x	x	x		x	x	x	x	x
3. Alloys											
a. Various types		x	x	x	*		x	x	x	x	x
b. Properties and uses				x			x		x	x	x
4. Corrosion of metals			x	x	x						
5. Metal oxides											
a. Solubilities			x	x				x			
b. Reaction with water	z		x	x				x			
c. Reaction with acids	z	x	x	x							
6. Bases (metal hydroxides)											
a. Preparation			x	x				x	x		x
b. Solubilities		x	x	x				x	x		x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
7. Salts											
a. General methods of preparation											
Acid with metal oxide	z		x	x					x		x
Acid with metal hydroxide	z		x	x							x
Acid with salt	z		x	x				x			x
The alkali metals											
1. Relationships and valence		x	x	x	x	x	x	x	x	x	x
2. Chemical activity of group		x		x	x	x	x	x	x	x	x
3. Sodium											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Sodium metal — preparation											
Castner process		x	x	x		x	x	x		x	x
Downes cell		x	x	x	x		x	x	x	x	
c. Sodium metal											
Reducing agent		x	x	x	x				x		
Reaction with water		x	x	x			x	x			x
Reaction with nonmetals		x	x	x	x		x	x			
Uses		x	x	x	x		x	x			
d. Sodium hydroxide											
Commercial preparation		x	x	x	x	x	x	x		x	x
Properties		x	x	x			x	x	x		
Industrial uses		x	x	x	x	x		x			
e. Sodium chloride											
Occurrence		x	x	x	x	x	x	x	x	x	x
f. Sodium carbonate — preparation											
Leblanc		x	x	x		x	x	x		x	
Solvay		x	x	x	x	x	x	x	x	x	x
g. Sodium bicarbonate											
Use in baking powder		x	x	x	x	x	x	x	x	x	x
h. Sodium peroxide											
Oxidizing agent		x	x	x	x	x		x	x		x
4. Potassium											
a. Occurrence		x	x	x			x	x	x	x	x
b. Potassium metal											
Commercial preparation			x	x			x	x	x		
Properties		x	x	x	x		x	x	x		x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
c. Potassium compounds											
Potassium hydroxide		x		x	x		x	x	x	x	
Potassium carbonate		x	x	x	x		x	x		x	
Potassium nitrate		x	x	x	x		x	x	x	x	
Potassium cyanide		x		x		x	x	x		x	
5. Lithium		m	m	m	m	m	m	m	m	m	m
6. Rubidium		m	m	m	m	m	m	m		m	
7. Cesium		m	m	m	m	m	m	m		m	
Alkaline earth metals											
1. Relationships and valence		x	x	x	x	x	x	x	x	x	x
2. Magnesium											
a. Magnesium metal											
Commercial preparation		x	x	x	x	x	x	x	x	x	x
Uses		x	x	x	x	x	x	x	x	x	x
b. Magnesium compounds											
Magnesium oxide		x	x	x	x	x	x	x	x	x	x
Magnesium hydroxide		x	x	x	x	x	x	x	x	x	x
Magnesium chloride		x	x	x	x	x	x	x	x	x	x
Magnesium carbonate		x	x	x	x	x	x	x	x	x	x
Magnesium sulfate		x	x	x	x	x	x	x	x	x	x
3. Calcium											
a. Occurrence		x	x	x		x	x	x		x	x
b. Calcium metal											
Preparation		x	x	x	x		x	x	x	x	x
Properties		*	x	x		x	x	x		*	
c. Calcium oxide											
Preparation		x	x	x	x	x	x	x	x		x
Uses, in cement especially		x	x	x		x	x	x	x	x	x
d. Calcium hydroxide											
In limewater		x	x		x	x	x	x	x	x	
Use in cement		x	x	x	x	x	x	x	x	x	
e. Calcium chloride											
Hydration		x	x	x	x	x	x	x	x	x	x
Use, a dehydrating agent		x	x	x	x	x	x	x		x	
f. Calcium carbonate											
In hard-water areas				x		x	x	x			
g. Calcium sulfate											
Plaster of Paris, gypsum			x	x	x	x		x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
4. Cements		x	x	x	x		x	x	x	x	x
5. Hard water											
a. Causes	z	x	x	x	x	x	x	x	x	x	x
b. Industrial problem		x	x	x	x	x	x	x	x	x	x
c. Reaction with soap	z	x	x	x	x	x	x	x	x	x	x
d. Treatment	z	x	x	x	x	x	x	x	x	x	x
6. Barium											
a. Occurrence		x	x	x	x	x	x	x		x	x
b. Barium hydroxide, laboratory use		x	x	x		x	x	x		x	
c. Barium sulfate — in paint		x	x	x	x	x	x	x	x	x	x
7. Beryllium											
a. Occurrence		x	x	x	x		x	x	x	x	x
b. Use in alloys		x	x	x	x	x	x	x	x	x	x
8. Strontium — occurrence		x	x	x	x	x	x	x	x	x	x
Aluminum											
1. Chemical relationships		x	x	x		x		x		x	x
2. Occurrence		x	x	x	x	x	x	x	x	x	x
3. Aluminum metal											
a. Metallurgy, Hall process		x	x	x	x	x	x	x		x	x
b. Physical properties		x	x	x	x	x	x	x	x	x	x
c. Chemical properties		x	x	x		x	x	x	x	x	x
d. Uses		x	x	x	x	x		x	x	x	x
4. Aluminum hydroxide											
a. Preparation		x	x	x	x	x	x	x	x	x	
b. Uses		x	x	x	x	x		x	x	x	x
5. Aluminum oxide, an abrasive		x	x	x	x	x	x	x	x	x	x
6. The alums (or aluminum sulfate)											
a. Composition		x	x	x	x	x	x	x	x	x	x
b. Uses			x	x	x		x	x	x	x	x
7. Aluminum hydrogen silicate		x	x	x	x	x	x	x	x	x	x
Rare earth metals — occurrence and uses (if any)		x	x	x	x			x		x	x
Tin, lead, and germanium											
1. Family relationships		x	x	x		x		x	x	x	x
2. Tin											
a. Occurrence		x		x	x	x	x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. Tin metal											
Metallurgy		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x		x	x	x	x	x	x
Uses		x	x	x	x		x	x	x	x	x
c. Tin compounds											
Tin oxides		x	x	x		x		x	x	x	x
Stannic chloride, mordant		x	x	x	x	x	x	x	x	x	x
3. Lead											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Lead metal											
Metallurgy		x	x	x	x		x	x	x	x	x
Properties		x	x	x	x	x	x	x		x	x
Uses		x	x	x	x		x	x	x		x
c. Lead compounds											
Oxides, in glass and paint		x	x			x	x	x	x	x	x
Carbonate, used in paint		x	x	x	x	x	x	x	x	x	x
d. Lead poisoning		x	x	x	x		x			x	x
Copper, gold, and silver											
1. Chemical relationships			x			x	x	x		x	x
2. Copper											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Copper metal											
Metallurgy		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x	x	x	x	x	x	x	x
Uses		x	x	x	x	x	x	x	x	x	
Alloys		x		x	x	x		x	x	x	x
c. Copper compounds											
Oxides and hydroxides		x	x	x		x	x	x	x	x	x
Cupric and cuprous salts		x	x	x		x	x	x	x	x	x
d. Complex ions		x	x	x	x	x	x	x			x
3. Silver											
a. Occurrence		x	x	x	x	x	x	x	x	x	
b. Silver metal											
Metallurgy		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x	x	x	x	x	x	x	x
Uses		x	x	x	x	x	x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
c. Silver nitrate											
Preparation		x	x	x		x	x	x	x		x
Uses				x		x	x	x	x		
d. Complex ions		x	x	x	x	x	x	x			x
e. Photography		x		x	x	x	x	x	x	x	x
4. Gold											
a. Occurrence		x		x	x	x	x	x	x	x	
b. Methods of extraction		x	x	x	x	x	x	x	x	x	x
c. Properties			x	x	x	x	x	x	x	x	x
d. Compounds		x		x		x		x	x	x	x
e. Complex ions		x	x	x		x	x	x		x	x
Zinc, mercury, and cadmium											
1. Chemical relationships			x			x		x	x	x	x
2. Zinc											
a. Occurrence		x		x	x	x	x	x		x	x
b. Zinc metal											
Metallurgy		x	x	x	x	x	x	x		x	x
Properties		x	x	x		x	x	x	x	x	x
Uses		*	*	x	x	x	x	x	x	x	x
c. Zinc compounds											
Zinc oxide, uses		x	x	x	x	x	x	x	x	x	
Zinc hydroxide, amphoteric		x	x	x	x	x	x	x	x	x	x
Zinc chloride, uses		x	x	x	x	x	x	x	x	x	x
Zinc sulfate, uses		x	x	x	x	x		x	x	x	x
3. Mercury											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Mercury metal											
Metallurgy		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x	x	x	x	x	x	x	x
Uses		x	x	x	x	x	x	x	x	x	
c. Mercuric and mercurous compounds											
Mercuric oxide		x	x		x	x	x	x	x	x	x
Mercuric chloride, poison		x	x	x	x	x	x	x	x	x	x
Mercurous chloride		x	x	x	x	x	x	x	x	x	x
Mercurous sulfide		x	x	x		x	x	x	x		x
4. Cadmium											
a. Occurrence		x		x		x	x	x	x	x	

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. Metallurgy		x	x	x		x	x	x	x	x	
c. Use in low-melting alloys		x	x	x	x	x	x	x	x	x	x
Chromium, molybdenum, tungsten, and uranium											
1. Chromium											
a. Occurrence		x		x	x	x	x	x	x	x	x
b. Chromium metal											
Properties		x		x	x		x	x		x	x
Uses, plating and alloys		x	x	x	x	x	x	x	x	x	x
c. Chromium compounds											
Chromates		x	x	x	x		x	x	x	x	x
Dichromates		x	x	x	x	x	x	x	x	x	x
Chromic compounds		x		x	x	x	x	x	x	x	x
Chromous compounds		x		x	x	x	x	x		x	x
2. Molybdenum		x	x		x		x	x	x	x	x
3. Tungsten, uses		x	x	x	x	x	x	x	x	x	x
4. Uranium — radioactivity		x	x	x			x	x	x	x	
Vanadium, columbium, tantalum, and protoactinium		m	m		m	m	m	m	m	m	m
Manganese											
1. Occurrence		x		x		x	x	x	x	x	x
2. Manganese substance, use		x	x	x	x		x	x	x	x	x
3. Manganese compounds											
a. Manganese dioxide		x	x	x	x	x	x	x	x	x	x
b. Manganous and manganic salts		x	x	x	x	x	x	x	x	x	x
c. Manganates		x	x	x	x	x		x	x	x	
d. Permanganates		x	x	x	x		x	x	x	x	x
Potassium permanganate		x	x	x	x		x	x	x	x	x
Iron, nickel, and cobalt											
1. Chemical relations		x		x		x	x	x		x	x
2. Iron											
a. Occurrence		x	x	x	x	x	x	x	x	x	x
b. Metallurgy											
Blast-furnace reduction		x	x	x	x	x	x	x	x	x	x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Cast iron, properties and uses		x	x	x	x	x	x	x	x	x	x
Wrought iron, properties and uses		x	x	x	x	x	x	x	x	x	x
3. Steel											
a. Production											
Bessemer process		x	x	x	x	x	x	x	x	x	x
Open-hearth process		x	x	x	x	x	x	x	x	x	x
Electric furnace		x	x	x	x	x	x	x	x	x	
b. Tempering of steel		x	x	x	x	x	x	x	x	x	x
c. Various types of steel		x	x	x	x	x	x	x	x	x	
4. Iron compounds											
a. Ferrous compounds		x	x	x	x	x		x	x	x	x
b. Ferric compounds		x	x	x	x	x	x	x	x	x	x
c. Cyanides											
Potassium ferrocyanide		x		x	x	x	x	x	x	x	x
Potassium ferricyanide				x	x	x		x	x	x	x
5. Inks											
a. Preparation		x	x	x			x	x	x	x	
b. Reaction in air		x	x	x			x	x	x	x	
c. Ink removal		x	x				x	x	x	x	
6. Cobalt, occurrence and properties		x	x	x	x	x	x	x	x	x	x
7. Nickel											
a. Occurrence		x		x	x		x	x	x	x	
b. Nickel metal											
Metallurgy		x	x	x	x	x	x	x	x	x	x
Properties		x	x	x	x	x	x	x	x	x	
Use in plating		x	x	x	x	x	x	x		x	x
Use as a catalyst		x	x	x	x	x	x	x	x	x	x
Platinum metals											
1. Occurrence		x		x		x	x	x		x	x
2. Platinum, properties and uses		x		x	x	x	x	x	x	x	x
3. Related metals, their uses		x		x		x	x	x	x		x
ORGANIC COMPOUNDS											
Introduction to organic compounds											
1. History		x		x	x	x					x

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
2. Basis for classification	X	x		x							
3. Occurrence in nature	X										
4. Compared with inorganic	X										
5. Structural formulas											
a. Uses	X	x	x	x	x	x	x	x	x	x	x
b. General structural features	X	x	x	x	x	x		x		x	x
c. Open chain versus cyclic	X				x	x					x
6. Survey of important classes	X					x					x
Hydrocarbons											
1. Typical hydrocarbons, with formula representation	X	x					x	x			
2. Saturated versus unsaturated	X		x		x	x	x	x	x		x
3. Homologous series		x	x	x	x	x	x	x	x	x	x
a. Paraffin series		x	x	x	x			x	x	x	x
b. Ethylene series		x	x	x	x				x	x	x
c. Acetylene series		x	x	x						x	x
4. Isomerism		x	x	x	x	x					x
5. Common hydrocarbon mixtures	X	x	x	x			x		x	x	
6. Chemical behavior											
a. Reaction with oxygen	X	m	m								
b. Reaction with halogens	X	x	x				x	x	x		x
c. Polymerization			x		x		x	x	x		
7. Methyl and ethyl radicals	X	x	x				x				
8. Petroleum products and fuels											
a. Refining and cracking		x	x	x			x	x	x		
b. Gaseous fuels			x	x			x	x	x	x	
Flames and burners			x	x			x	x	x	x	
Gasoline		x	x	x			x		x	x	
Motor fuels		x	x	x			x		x	x	
9. Rubber — natural and synthetic		x		x			x	x	x		
Halogen derivatives											
1. Important halogen derivatives	X	x	x				x	x	x		
2. Naming of derivatives	X	x						*			
Alcohols											
1. Typical alcohols, with formulas	X	x	x	x	x		x			x	x
2. As hydroxides	X		x		x		x	x	x	x	

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
3. As nonelectrolytes	X						x	x			
4. Oxidation to aldehydes and ketones	X	z	z	z				z	z		
5. Primary and secondary alcohols			x	x	x						x
6. Important alcohols											
a. Methyl alcohol	X	x	x	x	x		x		x	x	x
Preparation	X	x	x	x	x		x		x		x
Properties	X		x	x			x		x		
Industrial uses	X		x	x	x		x		x		
Physiological effect	X		x	x					x		x
b. Ethyl alcohol	X	x	x	x	x		x	x	x	x	x
Preparation	X	x	x	x	x		x	x	x		x
Properties	X		x	x			x		x		
Uses	X		*	*	*		x		x		*
Physiological effect	X			x							
Regulation of sale				x			x		x		
c. Isopropyl alcohol				x			x				
d. Glycol			x	x			x		x		
e. Glycerol, source and uses	X		x	x			x		x		
Ethers											
1. Typical ethers, with formulas	X	x	x	x							x
2. Ethyl ether	X	x	x	x			x	x	x		x
a. Preparation			x	x			x		x		
b. Properties	X			x			x	x	x		
c. Uses	X		*	*			*	*	*		*
Aldehydes											
1. The aldehyde group	X	x	x	x	x		x	x	x	x	
2. Preparation	X		x	x	x						
3. Oxidation to acids	X	x			m						x
4. Formaldehyde	X	x	x	x			x	x	x	x	
a. Properties		x					x	x	x		
b. As a reducing agent	X								x	x	
c. Uses											
As a disinfectant	X	m	m					x		x	
Industrial				x	x			x		x	
5. Aldehyde sugars	X										

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Ketones											
1. The ketone group	X	x		x			x	x	x		
2. Preparation from alcohols	X			x							
3. Oxidation of ketones	X										
4. Acetone	X	m		x			x	x			x
5. Fructose as a ketone	X										
6. Ketones of physiological importance	X										
Organic acids											
1. Common acids with formulas	X	x	x	x	x		x	x	x	*	x
2. Typical atom group	X	x	x	x	x			x	x	x	x
3. Ionization as weak acids	X									x	
4. Preparation from alcohols	z	x	x	x				x		x	
5. Fatty acids	X			m			x		x		x
6. Amino acids	X	x									
Organic salts and esters											
1. Differentiated	X								x		
2. Esters											
a. Preparation		x	x	x	x		x	x	x		
b. Fats as esters	X	m	x	x			x		x		
c. Common drugs	X										
d. Flavors and perfumes	X	x	x	x	x		x				
Cyclics or aromatic compounds											
1. Structural features											
a. The benzene ring	X		x	x		x	x	x	x	x	
b. Structural formulas, to show relationships	X		x	x							x
c. Naming — ortho-, meta-, para- positions			x	x							x
2. The coal-tar mixture	X			x			x		x	*	
3. Aniline and derivatives		x		x				x			
4. Phenols		x	x	x			x	x			
5. Uses											
a. Common drugs and disinfectants	X										

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. Dyes											
Commercial			x	x							
Bacterial stains	X										
c. Resins and plastics			x	x				x	x	x	x
d. Explosives				x				x	x	x	x
Carbohydrates											
1. Occurrence	X	x	x		x			x	x	x	
2. Synthesis in plant cells	X	x	x			x		x		x	
3. Chemical composition											
a. Elements	X	x	x	x	x				x	x	
b. Characteristic groups	X	x	m	x							x
4. Classification as mono-, di-, and polysaccharides	X	x		x			x	x	x	x	x
5. Solubilities											
a. Solution of sugars	X										
b. Colloidal dispersion											
Of starch	X	x	x					x	x		
Of glycogen	X										
c. In relation to osmosis and diffusion through membranes	X										
6. Monosaccharides											
a. Glucose, properties, etc.	X	x	x	x	m		x	x	x	x	m
b. Fructose, properties, etc.	X	x	x	x	m		x	m		x	m
c. Galactose, properties, etc.	X										
d. As reducing agents	X	x		*			*	*			
With Fehling reagent	X	x		x			x	x			
With Benedict's reagent	X										
Fermentation	X	x			m		x	x	x		
Commercial preparation of glucose					x		x	x	x	x	
7. Disaccharides											
a. Sucrose, properties, etc.	X	x	x	x	x		x	x	x	x	m
b. Lactose, properties, etc.	X	x		x				m	x	m	
c. Maltose, properties, etc.	X			x				m	x	m	
d. Hydrolysis	X	*		x	*		*	m	x	*	
e. As reducing agents	X	x									
8. Polysaccharides											
a. Starches and dextrins											

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
Properties in general	X	x	*	x	x		x	*	x	x	m
Hydrolysis	X	x	m	x					x		
Reaction with iodine	X	x		x				x			
Starches as foods	X		x	x			x	x		x	
Starches in laundry			m	m			m	m		m	
Dextrins in mucilage				m			m			m	
b. Glycogen											
Properties in general	X			x							
Hydrolysis	X			x							
c. Cellulose											
Cellulose molecules			x	x						x	x
Hydrolysis				x							
Paper manufacture		x	x	x			x	x	x	x	x
Cellulose nitrate		x	x	x			x			x	x
Cellulose acetate		x	x				x			x	x
Viscose process		x	x	x			x		x	x	x
Fats and related compounds											
1. Occurrence	X		x		x					x	
2. Fats and oils	X		x	x			x		x	x	
3. Fats as esters	X	x	x	x	x		x	x		x	x
4. Fatty acids	X		x	x			x	x	x	x	x
5. Saturated versus unsaturated fats	X		m								
6. Solubilities and their importance	X										
7. Emulsification	X										
a. In cleaning procedures	X										
b. Physiological importance	X										
8. Chemical behavior											
a. Hydrolysis	X							x			
Physiological importance	X										
b. Hydrogenation											
Reaction involved	X			x				x		x	
Commercial importance	X			x	z		z	x	*	x	
c. Reaction to make soap	X	*	x	x	x		x	x	x	x	x
9. Soaps and detergents											
a. Manufacture of soap			*	x	m		x	x	x	x	
b. Cleansing action of soaps		z		x	*		z	x	x	x	
c. New detergents				x			x	x	x		

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
10. Related compounds											
a. Cholesterol, solubilities and physiological importance	X										
b. Ergosterol and vitamin D	X	z		z	m		z				
c. Phospholipins and their physiological importance	X										
d. Waxes	X										
Proteins											
1. Essential components of living cells	X			x	x			x			x
2. Synthesis within plant cells	X										
3. Chemical composition											
a. Elements	X			x	x						x
b. Amino acids	X			x			x	x			x
c. Amino-carboxyl linkage	X				x			x			
4. Hydrolysis	X				x			x			
5. Essential amino acids	X										
6. Classification of proteins	X										
7. Albumins and globulins	X										
a. Occurrence	X										
b. Solubilities	X										
c. Physiological importance	X										
8. Chemical behavior											
a. Coagulation by heat	X							x			
In cookery	X							x			
In cleaning	X										
In urinalysis	X										
In disinfection	X										
b. Amphoteric action	X										
c. Reaction with picric and tannic acid	X										
d. Reaction with salts of heavy metals	X										
9. Applications of the above reactions (c. and d.)											
a. In disinfection	X										
b. In poisoning	X										
10. Nitrogen cycle	X	x		x	x		x		x		

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
PHYSIOLOGICAL CHEMISTRY											
Food and nutrition[3]											
1. Components of food		x		x				x	x	x	x
2. Function of food				x	x		x	x	x		
3. Caloric requirements		x		x	x		x	x			
4. Composition and caloric values for specific foods		x		x			x	x	x	x	
5. Carbohydrates as foods	z	x			x		x		x	x	
6. Fats as foods	z				x		x			x	
7. Proteins as foods	z	x			x		x			x	
8. Mineral content of food		x		m	x		m			x	
9. Vitamins		*		*	x		x	x	*	*	*
10. Selection of diet		*					*	*			
11. Hormones		v			v		m		v	v	v
Chemistry of digestion											
1. Importance of digestion	X										x
2. Physical factors influencing chemical digestion	X										
3. Salivary digestion											
a. Reaction involved	X	x						x			
b. Functioning enzymes	X	x					x	x		x	
c. Favoring conditions	X										
d. Continued in stomach	X	x									
4. Gastric digestion											
a. Enzymes in gastric juice	X	x					x	x		x	
b. Function of hydrochloric acid	X										
c. Protein digestion											
Reactions involved	X	x						x			
Favoring conditions	X										
d. Digestion of fats	X							x			
5. Intestinal digestion											
a. Enzymes provided by											
Pancreatic secretion	X	v					v	v		v	
Intestinal secretion	X	v					v			v	

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[3] The study of foods and nutrition in the nursing curriculum would be covered by the course in "Nutrition, Foods, and Cookery."

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. Bile, composition and function	X	m					v				
c. Carbohydrate digestion											
Starches and dextrins	X	x					v	v			
Celluloses	X										
d. Fat digestion	X	x			v		x	v			
e. Protein digestion	X	x			v		v				
f. Favoring conditions	X										
g. End products	X	x			v		v	v		v	
h. Conditions favoring the completion of digestion	X										
Functioning and fate of glucose, fats, and proteins in the cells[4]											
1. Glucose metabolism											
a. With oxygen in energy production	X										
Quantitative relationship	X										
Functioning of insulin	X										
b. Glycogen in the liver											
Synthesis	X										
Function	X										
c. In muscle cells											
Intermediate metabolism	X										
Lactic acid and fatigue	X										
Synthesis of fat from glucose	X										
d. Glycogen — lactic acid cycle	X										
2. Fat metabolism											
a. Synthesis within tissue cells	X										
b. With oxygen in production of energy, quantitative	X										
c. Ketosis (in detail)	X										
d. Stored fat, sources and functions	X										
3. Protein metabolism											
a. Essential functions	X										

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[4] The textbooks in general chemistry make no attempt to deal with this material beyond very limited reference to certain facts in the section on "Food and Nutrition."

Outline of Topics	CG	1	2	3	4	5	6	7	8	9	10
b. With oxygen in production of energy, quantitative	X										
c. Intermediate metabolism	X										
d. Metabolism of nucleoproteins	X										
4. End products of metabolism											
a. Matter products and pathways of elimination	X										
b. Energy products, functions and fate	X										
Physiological importance of salts and their ions[5]											
1. Important ions and their sources	X										
2. Some important functionings											
a. In relation to digestion	X										
b. Buffer action	X										
c. Respiratory control factors	X										
d. Control of osmosis	X										
e. Response of nerve and muscle cells	X										
f. Metabolism in bone cells	X										
g. Other functions of specific ions or elements	X										
3. Elimination of salts	X										

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[5] See footnote 4.

INDEX

Academic standards, 61, 62–63
  traditions, 14–15, 55–58
  versus professional, 14–17, 50, 55–59
Acids, bases, and salts, study of, 123–128, 227
  organic acids and salts, 136–137, 141–142, 245
  physiological functioning of, 100–101, 202, 206–211, 251
  reactions of, 124–125
Admission standards for schools of nursing, accredited, 7
  chemistry prerequisite, 12–13, 17, 46
  state board regulations, 7
  trends toward higher standards, 7–9
Affiliation of schools of nursing with colleges and universities, combined general and professional programs, 7–12, 17–18, 47–51, 114–115
  early preparatory courses, 33–34
  teaching of chemistry, 17–18, 47–51
  trend toward, 7, 9, 42, 46, 50
Alcohols, study of, 133–134, 140, 159, 243
Aldehydes and ketones, study of, 134–135, 140–141, 160–161, 244–245
Amines and amino acids, study of, 137, 142, 160
Applied courses in science, objections to, 57
  chemistry applied to nursing, 6, 10, 17–18, 35–39, 43, 49, 84, 95
Attitudes of college educators, to applied courses in science, 15, 57
  to science in the college curriculum, 55–59, 60–61
  to vocational studies, 55–59
Attitudes of nurse educators, to applied courses in chemistry, 16–17
Attitudes of nurse educators, to college courses in science, 9–11
  to standard courses in chemistry, 16–17

Basic curriculum, 4; *see also* Curriculums of schools of nursing
Blood chemistry, study of, 43, 101, 102–103; *see also* Environment for the living cell

Carbohydrates, study of, 145–148, 151–155, 246–247; *see also* Digestion; Metabolic reactions
Chemistry courses, general or inorganic, 6, 18, 107
    introductory college course, 5–6, 12–13, 18, 54–58
    use by schools of nursing, 38–39, 46–51
  organic, use by schools of nursing, 38–39, 48–49
  physiological (or biological), use by schools of nursing, 38–39, 48, 49
  proposed course for schools of nursing, 18, 90–107, 122–217
Chemistry course proposed for nurses —to follow introductory college chemistry, academic level of, 92–93
  basis for development of, 18, 91–92
  content, discussion of, 95–105
    outline of, 122–217
  general chemistry reviewed, plan for, 18, 91, 104–105
    review unit and topics, 123–128, 130, 144–145, 188–189, 212
  length of course, 97–98, 104, 122
  methods of instruction; *see* Teaching methods
  objectives of, 92

Chemistry course proposed for nurses, organic compounds, study of, 98–99, 104–105
  organization of, 104–105
  pathological chemistry, inclusion of, 102–104
  physiological chemistry, study of, 100–104
  placement in curriculum, 94–95
  selection of content, 95–104
    criteria for, 96–97
  study of, blood chemistry, 101, 102–103
    cyclic and heterocyclic compounds, 99–100
    enzymes, 100
    laboratory tests, 103–104
    metabolic reactions, 100, 105
    nomenclature, organic compounds, 99
    urinalysis, 101, 103–104
    vitamins, 100–102
Chemistry in the college curriculum, adjustment to academic environment, 62–63
  emphasis on education of chemists, 61, 62, 68, 72, 89
  factors influencing development, 59–66
  general chemistry, introductory course in, contribution to basic nursing program, 6, 13, 54–89
    content of, 73–87, 218–251
    criticism within the college, 68–69
    cultural contributions of, 56, 68
    evidence of standardization, 73–74
    student groups served by, 63–64
  sequence of courses, 58–59
Chemistry in the school of nursing, academic level of courses, 45, 92–93
  application to nursing, 16, 84–87, 90, 95, 101
    advantages of applied course, 46, 86–87
    advantages of hospital contact, 95
    preparation of teacher, 93, 114–115
Chemistry in the school of nursing, characteristics of chemistry courses, 35, 37, 38–39, 40–41, 43–46, 48–49
  contributions within the curriculum, social and cultural, 28–29, 49, 52
    to study of microbiology, 25, 94
    to study of nursing care, 26–28, 90, 112–113
    to study of nutrition, 24, 111
    to study of pharmacology, 25–26, 99, 111
    to study of physiology, 23–24, 94, 110–111
  criticism of prevailing courses, 5
  essential for professional preparation, 4, 51, 108–110
  functions of the chemistry course, 92, 108
  history of development, 32–42; *see* History
  increasing importance of study of, 29–31
  integration of, 16, 41, 46, 90, 105, 108–115
  interrelations within curriculum, 23–29, 94–95, 110–113
  limitations of formal course, 92, 108
  objectives of chemistry course, 51–53; *see also* Objectives
  outline in a *Curriculum Guide for Schools of Nursing*, 13–14, 38–39, 96–98
  placement of chemistry course, 94–95, 110
  responsibility of faculty for, 5, 50
  selection of content, 11, 38–39
  with college chemistry prerequisite, need to supplement, 6, 50, 87–88
  without college chemistry prerequisite, 17–18, 107
Chemotherapy, 30, 163, 166
Clinical nursing program, applications of chemistry in nursing, 26–28, 108–110, 112–115, 118
  co-operation of science teachers in, 113–115
  exploration needed, 115–116

Clinical nursing program, science foundation for, 10, 20–21, 95, 113, 118

College chemistry in relation to nursing curriculum, credit for, 5, 10, 38, 41–42, 47, 117
  criticism of courses modified for nurses, 69
  evaluation of college offering, 14–17, 73–88
    need for, 5–6, 17, 47, 54
  in prenursing programs, 12, 46
  in programs leading to degrees, 47–50
  in 3-year schools of nursing, 46–47
  prerequisite for admission, 12–13, 17, 46
  prospects for use of, 50–51
  use of standard college courses, as foundation for applied course, 18, 91, 94
    claims for superiority of, 9–10, 15
    disadvantages of, 10–11, 16, 115
    in degree programs, 47–50
    in 3-year nursing programs, 46–47

College courses in biological and physical science, for professional education, 4, 11
  use by schools of nursing, 11

Collegiate schools of nursing; *see* Affiliation of schools of nursing with colleges and universities

Curriculum Guide for Schools of Nursing, 13, 18, 38, 76, 84, 91, 96, 99, 101; *see also* National League of Nursing Education, curriculum studies

Curriculums of schools of nursing, basic curriculum, defined, 4
  breaking barriers between courses, 110–111
  chemistry course proposed for, discussion of, 90–107
    outline for, 122–217
  combined general and professional programs, 9, 12, 17–18, 47–50, 114–115
  correlation within, 110–111
  courses in biological and physical science, 4, 20–21, 110–111

Curriculums of schools of nursing, of professional standard, 4
  use of college chemistry in, 5–6, 12–19, 46–50, 54, 91, 94

Cyclic and heterocyclic compounds, study of, 99–100, 157–167, 245–246

Digestion, study of, 23, 180–187, 249–250

Drugs, study of, 25, 157, 162–163, 166

Education, general, combination of cultural and vocational, 57
  in relation to preparation of nurses, 6, 7
  in relation to study of science, 56–57, 68
  in relation to vocational preparation, 57
  liberal arts tradition, 55–58

Education of nurses; *see also* Professional education, advanced professional study, 117
  apprenticeship system, 21
  clinical program, 108–116
  cost of inadequate preparation in science, 118
  emphasis on the practical, 16, 32, 35–36
  general and professional program, 7, 12, 17–18, 47–50, 114–115
  in service education, 116
  in hospital schools, 21, 32, 95
  need for better preparation in science, 21–23
  subordination to service needs of hospitals, 21, 32
  value of hospital experience, 21

Education, professional; *see* Professional education

Education, vocational, attitudes of college educators, 6, 15, 55–59
  motivation to study of science, 56
  recognition in college curriculum, 56
  vocational courses in colleges, 58–59

Educational program of schools of nursing; *see* Curriculums of schools of nursing

Energy, study of, 24, 79–80, 105, 130–132, 190, 220–221
Environment of the living cell; *see also* Blood chemistry
  study of, 199–205
    buffer systems, 24, 202
    composition of blood, 200
    functioning of kidneys, 24, 202
    hydrogen—ion concentration of blood, 201–202
    oxygen-carbon dioxide exchange, 24, 200–201
Enzymes, study of, 24, 100, 181–182, 185
Esters, study of, 136–137, 245
Evaluation of introductory courses in general chemistry, as foundation for study of nursing, 14–17
  as the foundation for a course for nurses, 74
  compared with course outline in a *Curriculum Guide for Schools of Nursing*, comparison of content, 76–81, 218–251
    need for supplementary course, 87–88
    objectives compared, 67–68, 70–71
    organization, 83–84
    range of study, 82–83
    time factor, 83
    use of applications, 85–87
  need for evaluation, 5–6, 17, 47
  purpose of evaluation, 6, 18, 54
  study of textbooks in general chemistry, 74–88, 218–251
    assumptions, 74–75
    common core of content, 74–78
    detailed comparison of content, 218–251
    method of study, 75–76
    noteworthy differences, 78–81
    selection of textbooks, 75
    summary of findings, 76–88

Faculty of school of nursing, co-operation in teaching students, 113–115
  major interest of, 21
Faculty of school of nursing, preparation of, advanced study, 117
    in science, 111, 113, 117
    in service education, 116
    inadequate preparation a handicap, 113
  responsibility for curriculum, 17, 50
  responsibility for teaching, 95, 108–110, 112–113
  science instructors; *see also* Teachers of chemistry
    co-operation in clinical teaching, 113–114
    preparation of, 39–41, 111
    use as consultants, 114
Fats, study of, 148–150, 153–155, 247–248

Head nurses and supervisors; *see* Faculty of school of nursing
History, chemistry in colleges, admission to curriculum, a new intellectual experience, 60
    demands for practical science, 59–60
    in medical schools, 59
    in technical institutes, 60
    opposition to, 60–61
  influences affecting development, adjustment to academic environment, 62–63
    coming of elective system, 61–62
    German universities, 62
    Morrill Act, 61
    preparation of teachers, 62
    struggle for recognition, 60, 63
  chemistry in schools of nursing, current practice, 42–51
    curriculum studies, National League of Nursing Education, 34–35, 37–39
    early preparatory courses, 33–34
    early textbooks, 33, 35–36
    in Boston Training School, 32
    in Farrand Training School for Nurses, 32
    in Johns Hopkins Training School, 33
    in Nightingale School, London, 32

History, chemistry in schools of nursing, in Pennsylvania Hospital School of Nursing, 32
    incidental instruction in chemistry, 32–33
    interest in college chemistry, 41–42
    Report of Committee on Nursing and Nursing Education in United States, 36–37, 39
Hospital schools of nursing, education in pioneer schools, 32
  educational opportunities of, 21, 95
  students with college preparation, 9, 12, 17
Hydrocarbons and derivatives, study of, 131–133, 138–140, 158–159, 243

Integration, of chemistry in study of nursing, 16, 41, 46, 51, 92, 108–110, 112–114, 119
  of general chemistry in applied course, 18, 88, 92, 105
  the great opportunity for integration, 112

Ketones, study of; *see* Aldehydes and ketones

Laboratory study, clinical tests, the nurse's interest in, 31, 103–104
  early opposition to, 61
  facilities of college, 9
  facilities of school of nursing, 94
  functions of, 56, 66
  in an early textbook for nurses, 33
  introduction of, 62
  selection of experiments, 106
Laboratory, suggestions for study in proposed courses, alcohols, 134
  aldehydes and ketones, 135
  buffer systems, 202
  carbohydrates, 148
  cyclic compounds, 160
  digestion, 184
  enzymes, 181
  fats, 150
  hydrocarbons, 133
  metabolism, 194
Laboratory, organic acids, salts, and esters, 136
  proteins, 171
  urinalysis, 194
Length of chemistry courses, 33–34, 36, 38, 43, 45, 47, 48–50, 83, 97–98, 104, 122
Library facilities, 93

Medical science, in relation to nursing, 21–23, 29–31, 52, 113
  Introduction to Medical Science, a course for nurses, 102, 111
  progress of, influences nursing practice, 21–23, 29–31
    modern developments, 21–22, 29–31
    necessitates changes in education of nurses, 21–23, 31
Mental discipline, 15 55, ,61, 65
Metabolic reactions, study of, 27, 100, 105, 188–198, 250–251
Metals, study of, metal elements, 235–242
  reactions from contacts with, 124
Method of study; *see also* Evaluation of introductory course in general chemistry; Textbook study
  selection of content for proposed course for nurses, 95–104
    criteria for, 96–97
  statement of problem, 5–6
  study of textbooks, 74–76, 218–251
    assumptions, 74–75
    comparison of content, 75–76, 218–251
  summary of plan of study, 18–19
  use of course outline in *Curriculum Guide for Schools of Nursing*, 13–14, 18, 91, 95–97
Motivation of students, 11, 46, 56, 58, 91, 95, 109

National League of Nursing Education, admission standards for schools of nursing, 8
  curriculum studies, *Curriculum for Schools of Nursing*, 37–38
    Curriculum Guide for Schools of Nursing, 13–14, 38–39

National League of Nursing Education, curriculum studies, *Standard Curriculum for Schools of Nursing*, 34–35, 37
  educational program of professional school, 3
  educational qualifications of student nurses, 8
  efforts to attract college women to nursing, 41–42
Nomenclature, of organic compounds, study of, 99, 130
Nurses as professional workers, knowledge of scientific principles, 3, 26, 31, 108, 112
  in co-operation with physicians, 22, 28, 118
Nursing education; *see* Education of nurses
Nursing service for patients, better quality of, 28, 90, 108, 117
  intelligent nursing, 25, 26–27, 92
  safe and effective nursing, 4, 90, 118

Objectives of chemistry courses, in schools of nursing, compared with objectives of college courses, 67–68, 70–71
    discussion of, 67–68
    proposed course, major objectives, 51–53, 92
    proposed course, unit objectives, 123, 129, 144, 157, 168, 174, 199, 206, 212
    statements of, 51–52, 70–71
  introductory courses in (general) college chemistry, compared with objectives for course for nurses, 67–68, 70–71
    discussion of, 65–68
    statements of, 65–66
Organic chemistry, study of, 39, 50, 81–82, 98–99, 129–143, 242–248
Organization of chemistry courses, applied courses for nurses, in a *Curriculum Guide for Schools of Nursing*, 84
    proposed course for nurses, 104–105
Organization of chemistry courses, standard course in general chemistry, 83–85
Oxygen, study of, 80–81, 105, 189–190, 219–220

Pathological chemistry, study of, 103–104, 111, 188, 206
*p*H of solutions, study of, 79, 125–126, 230
Philosophy of education, academic versus professional, 14–17
  in relation to nursing education, 16
  liberal arts versus vocational, 55–58
  mental discipline, 15, 55, 61, 65
  pure science versus applied science, 57–58
  superiority of mind over matter, 57
  vocational preparation in general education, 57
Physiological chemistry, study of, 30, 39, 50, 82, 100–105
Pretest, use of, 125
Professional education, criticisms relating to, 58
  in relation to general education, 8, 12, 58
  in relation to grouping of students in courses, 63–64
  influence on college curriculum, 55–56
  of nurses, 3–4, 7–9, 18, 22–23, 87–90, 108
Professional growth, advanced study, 117
  independent reading and study, 4, 52, 71, 99
Professional status, dependent on education, 3, 109
  of nursing, 3–4, 7, 22, 31, 53, 112
Proteins, study of, 168–173, 248; *see also* Digestion; Metabolic reactions
Public health problems, contributions of chemistry course, 28, 52

Radioactive elements, biological interest, 30, 212–217
Radioactivity, study of, 77, 212, 224

Salts, study of, 100–101, 124–125, 136–137, 141–142, 202, 206–211, 251
Schools of nursing, admission to; *see* Admission standards
  affiliations with colleges and universities, 7, 9, 12, 42, 46, 50
  as professional schools, 3
  association with hospitals, economic dependence of school, 21, 32
    education subordinated to service, 21, 32
    educational opportunities, 21
    indispensable experience, 21
  responsibility to students, 50
Scientific method, training in, 52, 65, 68, 71–72
Solutions, true and colloidal, study of, 146–147, 225–227
State board regulations, admission standards, 7
Structural formulas, study of, 99, 129
Students in college chemistry courses, diversified interests of, 63–64
  grouping in sectioned courses, 64
  indifference toward non-science majors, 68–69
  motivated by vocational interests, 57, 58, 64, 67
Students in schools of nursing, credit for college courses, 10
  criticism of chemistry courses, 45, 91
  educational qualifications of, 8
  preference for degree programs, 9
Study and discussion, suggestions for, acids, bases, salts, and water, 126–128
  carbohydrates, 151–153
  cyclic and heterocyclic compounds, 163–166
  digestion, 185–187
  drugs and chemotherapy, 166
  environment of the living cell, 203–204
  enzymes, 185
  fats and detergents, 153–155
  metabolic reations, 194–197
  organic compounds, important classes of, 138–142
  proteins, 171–173
Study and discussion, radioactive elements, 215–216
  salts, important functions of, 209–216
  vitamins, 177–179
Studies, reports of, A. A. A. S. Committee on Improvement of Science Instruction for Purposes of General Education, 47, 67, 68–69
  Committee on the Grading of Nursing Schools, educational qualifications of students, 8
    teaching of science, 42
  Committee on Nursing and Nursing Education in the United States, university schools of nursing, 9
    teaching of chemistry, 36–37, 39
  Heil, Louis, "Determining Objectives of Science Instruction in General Education," 66
  National League of Nursing Education, Committee on Curriculum, a *Curriculum Guide for Schools of Nursing*, 13–14, 38–39
    Committee on Education, a *Curriculum for Schools of Nursing*, 37–38
    Department of Studies, educational qualifications of students, 8
    Education Committee, a *Standard Curriculum for Nursing Schools*, 34–35, 37
  Noll, Victor H., "Science Teaching on the College Level," 64, 67
  Nutting, M. Adelaide, *Educational Status of Nursing*, 34
    "The Education and Professional Position of Nurses," 34
  Petry, Lucile, "Basic Professional Curricula in Nursing Leading to Degrees," 9
  Smith, Otto M., "Accepted Objectives in Teaching General College Chemistry," 67

Teachers of chemistry, in colleges and universities, attitude toward grouping of students, 64

Teachers of chemistry, in colleges and universities, interest centers in the science, 62, 65–66, 87
    resistance to modification of courses, 47, 69
    specialists in the science, 9–10, 87
    statements of objectives, 65–66
  in schools of nursing
    non-nurse teachers, 39–40, 115
    nurses as science instructors, 40–41, 114
    preparation of, 37, 39–41, 114
  co-operation in clinical teaching, 113–114
Teaching facilities, 93–94
Teaching methods, application of principles, 85–87, 105–106
  emphasis on principles, 105–106
  emphasis on significant relations, 105–106
  laboratory study, 56, 62, 94, 106–107
  lecture and discussion, suggestions for, 125, 130, 145–147, 158–160, 162–163, 175–177, 189, 207, 213–214
  lecture and laboratory, flexibility within schedule, 106–107
    ratio of time, 106–107
    traditional distribution disregarded, 107
  lecture-demonstration, suggestions for, 97, 124, 131–137, 145–148, 169–171, 202
  study and discussion, 106; *see also* Study and discussion, suggestions for
Textbook study, discussion and tabulation of, acidimetry and alkalimetry, 230
  acids, bases, and salts, 227
  atomic and molecular weights, related theory, 76, 220–223
Textbook study, atomic structure, 77, 224
  chemical equilibrium, 77, 101, 229–230
  chemical shorthand, 76, 223–224
  electromotive chemistry, 231
  energy transformations, 79, 220–221
  food and nutrition, 249
  fundamental concepts, 76, 218–219
  ionization, 78–79, 101, 228–229
  metal elements, 235–242
  non-metal elements, 231–235
  organic compounds, 81, 242–248
  oxidation-reduction, 77, 230–231
  oxygen, combustion, and energy, 78, 80, 219–221
  periodic table, 77, 224
  *p*H of solutions, 79, 230
  physical states of matter, 221–222
  physiological chemistry, 82, 249–251
  radioactivity, 77, 224
  solutions, true and colloidal, 225–227
  water, 77, 224–225
Time for study, a necessity, 93
Trends in nursing education, affiliation with colleges and universities, 7, 9, 42, 46, 59
  higher admission standards, 6–9

University schools of nursing; *see* Affiliation of schools of nursing with colleges and universities
Urinalysis, study of, 33, 43, 101, 103–104, 111, 194

Vitamins, study of, 30, 101–102, 174–179, 249
Vocational education; *see* Education, vocational

Water, study of, 125–126, 224–225